

Introduction

ARS Annual Performance Report for FY 2008 and Performance Plan for FY 2009-2011

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 also completes program evaluations pursuant to the **President's Management Agenda (PMA)**. The PMA is designed to strengthen the management of Federal programs and increase program accountability. ARS has conducted a **Program Assessment Rating Tool (PART)** analysis on all the research conducted under Strategic Plan Goals. The PART assessment seeks to measure four aspects of a program: program purpose and design, strategic planning, program management, and program results/accountability. ARS is conducting ongoing PART improvement plans for each goal as well. Results can be seen on the website www.Results.gov.

Beginning in FY 2005, ARS' National Program Leaders (NPLs) and Area Directors annually review 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 helps the Agency identify low performing and/or low priority research. This information is used in shaping the annual budget; it is also be used to make future program management decisions. The R&D investment criteria are applied as follows:

- For **relevancy**, the NPLs assess 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 review 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 rely 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 use 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 assess 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; 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

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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.

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Strategic Goal 1:

Enhance International Competitiveness of American Agriculture

Expanding global markets for agricultural products is critical for the long-term economic health and prosperity of our food and agricultural sector. U.S. farmers have a wealth of natural resources, cutting-edge technologies, and a supporting infrastructure that result in a production capacity beyond domestic needs. Expanding global markets will increase demand for agricultural products and contribute directly to economic stability and prosperity for America's farmers.

To expand overseas markets and facilitate trade, various USDA agencies assist in the negotiation of new U.S. trade agreements, the monitoring and enforcement of existing trade agreements, the administration of market development and export promotion programs, and the adoption of science-based regulatory systems and standards. In supporting these USDA activities, ARS plays a significant role, particularly under Objective 1.3: Improve the Sanitary and Phytosanitary System to Facilitate Agricultural Trade. However, ARS research in this capacity falls under Goals 1 and Goal 4. In working to protect crops from diseases, ARS also enhances the international competitiveness of American agriculture. Therefore, ARS has elected to report this category of research under Objective 4.2: Reduce the Number, Severity, and Distribution of Agricultural Pest and Disease Outbreaks. Relevant information is reprinted under both Objective 1.3 and Objective 4.2 for the reader's convenience.

OBJECTIVE 1.1: EXPAND AND MAINTAIN INTERNATIONAL EXPORT OPPORTUNITIES

Activities related to this objective are primarily carried out by other USDA agencies.

OBJECTIVE 1.2: SUPPORT INTERNATIONAL ECONOMIC DEVELOPMENT AND TRADE CAPACITY BUILDING

Activities related to this objective are primarily carried out by other USDA agencies.

OBJECTIVE 1.3: IMPROVE THE SANITARY AND PHYTOSANITARY (SPS) SYSTEM TO FACILITATE AGRICULTURAL TRADE

Sanitary and Phytosanitary (SPS) barriers put in place to protect humans, animals, and plants from foreign pests, diseases, and contaminants continue to increase due to the lack of regulatory capacity in various countries and/or the lack of sound science. These technical barriers impede agricultural trade around the world. Reduced trade flows due to SPS barriers limit U.S. exports and efforts of developing countries to participate in and benefit from global trade. In response to these problems, USDA uses its extensive expertise and works closely with other U.S. agencies to strengthen regulatory coordination, streamline procedures to enhance trade, and encourage the use of sound science in addressing SPS and biotechnology issues.

ARS provides the sound scientific basis that USDA can use to work aggressively with its private sector trading partners and international organizations to develop a stronger system of international guidelines. These new guidelines will foster the widespread adoption of science-based regulatory systems, helping to protect the life and health of humans, animals and plants within the United States as well as facilitating trade.

Key Outcome: An improved global SPS system for facilitating agricultural trade.

The ARS research in support of Strategic Goal 1, Objective 1.3 is reported as Performance Measure 4.2.5 under Strategic Goal 4, Objective 4.2.

Strategic Goal 2:

Enhance the Competitiveness and Sustainability of Rural and Farm Economies

American consumers benefit from agricultural products that minimize their food costs and maximize their consumption choices. However, many within the agricultural production sector are suffering from low commodity prices that have remained relatively unchanged for decades, while the costs of fuels and other purchased inputs have continued to rise. The Nation's rural economic vitality depends on the ability of producers to profitably produce agricultural products, including food, fiber, industrial products, and fuels, while at the same time enhancing the natural resource base upon which crop and livestock production depends. Future financial success will depend on increasing productivity and production and conversion efficiencies, accessing new markets for specialized products, developing biobased technologies that provide new opportunities for U.S. farmers, and utilizing tools and information to mitigate risks and rapidly make adjustments to changing market conditions. Because there is great diversity in the farm sector driven by varying available resources, climate, and individual preferences, an equally diverse range of solutions is needed. Also, the needs, concerns, and opportunities of large farms may differ from those of smaller or intermediate sized farms, regardless of location. Therefore, research will need to provide producers options in terms of what is best for them for their respective circumstances.

ARS conducts basic and applied research to develop new and more efficient technologies and systems for producing and processing agricultural products that can enhance the efficiency and profitability of producers as well as provide improved and new products for consumers. ARS researchers work to produce biofuels and other biobased products that expand markets for agricultural products, reduce national dependence on foreign sources, and enhance environmental sustainability. ARS also promotes livestock and crop productivity through genetic and genomic research, and the development of technologies that enhance the economic value of agricultural products.

OBJECTIVE 2.1: EXPAND DOMESTIC MARKET OPPORTUNITIES

Technological progress is creating new and expanded markets for agricultural products. New technologies will provide consumers with new and improved food, textiles, and fibers. Biobased technologies promise new opportunities for U.S. farmers to take advantage of energy and industrial markets. Currently, U.S. agriculture is the source of various products such as biopolymers, industrial chemicals and films, and clean burning bioethanol and biodiesel that are derived from plants and livestock byproducts rather than petroleum or other nonrenewable natural resources. New markets are also emerging for products and strategies to mitigate environmental concerns, such as the use of carbon sequestration to offset greenhouse gas emissions. ARS is in a position to bring biological and physical sciences together with engineering in a coordinated research program to expand a variety of market opportunities,

particularly for the sustainable commercial production of bioenergy, biofuels, and biobased products.

Performance Measures

Measure 2.1.1 Create new scientific knowledge and innovative technologies that represent scientific/technological advancements or breakthroughs applicable to bioenergy.

Baseline 2004

Four technological breakthroughs or scientific advancements that make 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.

Target 2011

Cumulatively, 24 technological breakthroughs or scientific advancements that make 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.

Indicator 1

During FY 2008, ARS will develop new or improved, or more environmentally friendly processing technologies.

FY 2008 Accomplishments:

1. ARS scientists developed effective and low-cost on-farm pretreatment practices to improve the enzymatic digestibility of herbaceous biomass.

Impact: These practices allow farmers to produce and sell biomass feedstocks at a high return.

Indicator 2

During FY 2008, ARS will develop new or improved methods to measure or predict quality.

FY 2008 Accomplishments:

1. ARS scientists developed a new low-cost pretreatment technology that maximizes the yield of fermentable sugars.

Impact: Because pretreatment is one of the most costly steps in cellulosic biorefining, this pretreatment technology significantly increases the economic viability of cellulosic ethanol.

2. ARS scientists developed a membrane bioreactor to increase the normally slow rate of 5-carbon fermentation by 60 times.

Impact: A commercially-viable cellulosic ethanol facility must be able to convert both the 6-carbon and 5-carbon sugars into fuel, and so this ARS technology significantly lowers the capital cost requirements for a cellulosic ethanol biorefinery.

3. ARS researchers discovered and characterized a new enzyme that is an order of magnitude faster than other known enzymes in hydrolyzing the hemicellulose portion of biomass.

Impact: By significantly lowering the cost of producing fermentable sugars from biomass, this discovery increases the economic viability of cellulosic ethanol biorefining.

4. Ethanol-producing microorganisms in nature ferment either pentose or hexose sugars, but not both. And although a microorganism can be genetically engineered to convert both pentose and hexose sugars into ethanol, such recombinant strains are genetically unstable and do not work well in continuous fermentations. ARS researchers developed a stable, recombinant, ethanol-producing bacterium which ferments both pentose and hexose sugars. The bacterium produces cellulosic ethanol in a continuous manner over many months without any loss in productivity, plasmid stability or cell viability.

Impact: Continuous fermentors have as much as 2X higher productivity (g-EtOH/L-hr) than traditional batch fermentation systems. By enabling the continuous fermentation of biomass-derived sugars, this ARS-developed bacterium significantly lowers the capital investment requirements for cellulosic biorefining.

Indicator 3

During FY 2008, ARS will develop technologies leading to new or improved products from renewable resources and agricultural residues and wastes.

FY 2008 Accomplishments:

1. ARS scientists assessed production costs, farm income, net energy use, and environmental impacts of cellulosic ethanol production in the Upper Midwest for 4 crop systems: continuous corn (with and without stover harvest); continuous switchgrass; and an alfalfa-corn rotation. Although continuous corn (CC) had the highest ethanol yield and profit, it was the least energy efficient and led to the most erosion and N leaching. Alfalfa-corn (AC) produced less ethanol and lower profits, but was more energy efficient, had less erosion, and virtually eliminated N fertilizer use and leaching. Switchgrass created almost no erosion, was the most energy efficient, and was between CC and AC in N fertilizer use and leaching; but it was profitable only when selling prices or yields are high.

Impact: Policymakers can use the findings of this study to develop bioenergy crop assistance programs that effectively balance environmental, energy and economic goals.

Measure 2.1.1 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS reported on two 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.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Corn oil obtained by ethanol extraction contains valuable functional lipids that are not present in typical corn oil which is extracted using hexane.	The technology will be transferred to the CRADA partner.	Illinois Corn Marketing Board	The CRADA partner will enjoy higher profits from producing and selling this 'enhanced' corn oil.
A beta-xylosidase enzyme that is 10 times more active than any other reported. Beta-xylosidase enzymes breakdown major portions of ligno-cellulosic biomass into fermentable sugars.	patent application	Biorefineries for cellulosic ethanol or cellulosic butanol	Significantly lower cost for converting biomass into fuels such as ethanol.

Measure 2.1.1 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

develop improved biomass plants, sustainable biomass production systems, and efficient handling and storage technology for biomass feedstocks.

develop technology and systems that improve the efficiency, economics, and sustainability of energy production from agricultural biomass.

develop renewable energy technology and systems to meet on-farm and remote rural needs and to enhance the rural economy.

During FY 2010, ARS will

develop improved biomass plants, sustainable biomass production systems, and efficient handling and storage technology for biomass feedstocks.

develop technology and systems that improve the efficiency, economics, and sustainability of energy production from agricultural biomass.

develop renewable energy technology and systems to meet on-farm and remote rural needs and to enhance the rural economy.

During FY 2011, ARS will

develop improved biomass plants, sustainable biomass production systems, and efficient handling and storage technology for biomass feedstocks.

develop technology and systems that improve the efficiency, economics, and sustainability of energy production from agricultural biomass.

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.

Baseline 2004

Non-food, non-fuel biobased products derived from renewable agricultural resources represent a small fraction of the market for petroleum-based industrial products and some are not yet economically competitive. Also, many agricultural products are marketed as low-value commodities, with post-harvest spoilage decreasing return to producers. Healthy foods are often not convenient or readily accepted by significant numbers of consumers. In FY 2005, four new biobased products and food items with improved quality, nutritional or functional characteristics were developed by ARS and used by customers, both domestic and foreign.

Target 2011

Cumulatively, 20 new technologies developed by ARS and adopted for uses that provide food crops and products with higher quality and extended shelf life; convenient and acceptable healthy foods; non-food, non-fuel biobased products with cost and performance features comparable or superior to petroleum-based products; and valuable co-products from agricultural residues and processing wastes.

Indicator 1

During FY 2008, ARS will develop technologies leading to new or improved products from renewable agricultural resources, residues and wastes.

FY 2008 Accomplishments:

1. Researchers in Albany, California, worked with an industrial CRADA partner to commercialize patent-pending, fruit- and vegetable-based films in a variety of final food product applications. One of these applications is the use of the films as healthy, colorful alternatives to the seaweed wrap 'nori' in a novel line of Sunny California rolls on sale at Trader Joe's supermarkets around the country. Films were also sold commercially to a wide variety of up-scale restaurants, as well as for use as a healthy, flavorful glaze for hams and turkeys.

Impact: The CRADA partner received a large loan from the San Joaquin Valley Revolving Loan Fund to build the film manufacturing plant in Stockton, California, an area of high unemployment. Research by the ARS scientists helped the CRADA partner begin production in this new location this year, resulting in the hiring of four full-time professionals, two of whom are minorities.

2. ARS scientists in Albany, California, worked with a mushroom producer, through a CRADA, to implement and optimize processing conditions to naturally produce Vitamin D in mushrooms by brief exposure to ultraviolet B light. The process has been scaled up and one serving of the mushrooms contributes 100 percent of the Recommended Dietary Allowance (RDA) of Vitamin D for adults. Sensory results indicate that the acceptability of the treated mushrooms is equivalent to that of untreated mushrooms.

Impact: The mushrooms are scheduled to be released in the marketplace nationwide in the near future. This research will help meet American nutritional needs while adding value to mushrooms.

3. Over the past 4 years, researchers at Albany, California, worked with collaborators at the University of California at Davis, USDA Grain Inspection, Packers and Stockyard Administration (GIPSA) and the California Rice Research Board in the systematic investigation of the rice sample milling mechanism and the effect of milling parameters on the appraisal of rice milling quality. Based on the scientific knowledge and results obtained by the researchers, a new rice sample milling standard was implemented in October of 2007 by the USDA GIPSA.

Impact: The adoption of the new rice sample milling procedure adds an estimated value of over \$20 million each year to the rice industry in the United States.

4. ARS researchers in Albany, California, developed starch microbeads as slow-release agents to release miticides that control honeybee parasites. The microbeads contain heptanone and essential oils that control Varroa mites, using technology for making starch-based microspheres in a controlled, critical size range, from 1 to 10µm.

Impact: The starch foam microspheres are used to control parasitic mites in honeybee colonies and may also have useful pharmaceutical applications.

5. ARS scientists at Lubbock, Texas, developed high performance mulches for the green industry utilizing cotton gin byproducts and provided guidance on equipment layout and processing necessary to implement the technology for a soon-to-be built facility to produce hydromulch.

Impact: A hydromulch facility could result in a revenue stream of \$20 to \$30 per ton to cotton gins within the region of the plant. Value-added processing has resulted in a paradigm shift from thinking of gin byproducts as waste to considering the material as a revenue stream.

Indicator 2

During FY 2008, ARS will develop new or improved methods to measure or predict quality, or to sort by quality.

FY 2008 Accomplishments:

1. A low cost sorting device for wheat was built by engineers at Manhattan, Kansas, using a standard personal computer and color camera.

Impact: This sorter will help breeding programs isolate desirable kernels so that they can be propagated, which will result in faster releases of new and improved varieties of grain. Four wheat breeders in the United States have already adopted this system as their tool of choice for separating red and white wheat.

2. Engineers at Manhattan, Kansas, developed a system that can automatically select specific kernels with specific traits from populations.

Impact: These kernels can be used by breeders to develop cultivars with specific traits that will result in crops with improved agronomic performance and improved end-use quality. The selection of kernels can occur in a few minutes and does not require years of crossing required in current breeding programs. The system can also be used to measure the variability of quality within samples, providing valuable information to grain

handlers, storage managers, millers, and grain processors. The system has been applied to wheat and proso millet, and could apply to other grains.

3. In support of Federal and non-federal public breeding/screening programs, research conducted at East Grand Forks, Minnesota, analyzed between 14,000 and 15,000 advanced breeding lines for storage/processing quality. In collaboration with North Dakota State University and University of Minnesota, research conducted at East Grand Forks, Minnesota, contributed to the release of two new promising potato varieties Dakota Crisp and Dakota Diamond.

Impact: Both varieties offer significant benefits to both producers and processors and should be widely adopted by the potato industry.

4. Seed cotton moisture measurement system, "SMMS", is one application of broader technology that was developed by scientists at Lubbock, Texas. As developed, the SMMS is capable of being utilized in both seed cotton moisture sensing as well as cotton bale lint moisture sensing.

Impact: This technology has produced three U.S. patents. A material transfer agreement was completed with a commercial partner in 2008 to effectively implement the transfer of the technology to industry.

5. ARS researchers at Winter Haven, Florida, collaborated with a University of Florida strawberry breeder to develop flavorful fruit complementing the ripening period of the current commercial variety, strawberry 'Festival'. Strawberry advanced selections were evaluated for flavor, color and horticultural characteristics, including sensory and chemical analyses.

Impact: The collaborative research resulted in the development of fruit with constant superior eating quality during the ripening season of strawberries in Florida, and two strawberry advanced selections, 'Florida Elyana' and 'Florida Radiance', were released by the University of Florida

6. The Hard Red Spring and Durum Wheat Quality Laboratory at Fargo, North Dakota, contributed wheat end use quality data that helped lead to the development of improved wheat germplasm and subsequent release of new cultivars of spring, winter, and durum wheat bred for commercial production.

Impact: The impact lies in the release or potential release of five experimental lines of spring wheat in 2007/2008 and the commercial release of the cultivars 'Briggs' and 'Ada' in 2007.

Measure 2.1.2 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS 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 products; and valuable co-products from agricultural residues and processing wastes that are in use.

STRATEGIC GOAL 2

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
<p>Approximately 60 percent of Americans are deficient in Vitamin D. ARS scientists in Albany, California, worked with a mushroom producer, through a CRADA, to implement and optimize processing conditions to naturally produce Vitamin D in mushrooms by brief exposure to ultraviolet B light.</p>	<p>The process has been scaled up and one serving of the mushrooms contributes 100 percent of the RDA of Vitamin D for adults. Sensory results indicate that the acceptability of the treated mushrooms is equivalent to that of untreated mushrooms. The mushrooms are scheduled to be released in the marketplace nationwide in the near future.</p>	<p>Monterey Mushrooms, Inc. Watsonville, California</p>	<p>This research will help meet American nutritional needs while adding value to mushrooms.</p>
<p>There is a great need for developing appropriate standard rice sample milling and preparation procedures aimed at improving the consistency and accuracy of rice quality appraisal. Over the past 4 years, researchers at Albany, California, worked with collaborators at the University of California at Davis, USDA Grain Inspection, Packers and Stockyard Administration (GIPSA), and the California Rice Research Board in the systematic investigation of the rice sample milling mechanism and the effect of milling parameters on the appraisal of rice milling quality.</p>	<p>Based on the scientific knowledge and results obtained by the researchers, a new rice sample milling standard was implemented in October of 2007 by the USDA GIPSA.</p>	<p>USDA Grain Inspection, Packers and Stockyard Administration (GIPSA) and the California Rice Research Board.</p>	<p>The adoption of the new rice sample milling procedure adds an estimated value of over \$20 million each year to the rice industry in the United States.</p>
<p>ARS scientists at Lubbock, Texas, developed high performance mulches for the green industry utilizing cotton gin byproducts.</p>	<p>The ARS scientists provided guidance on equipment layout and processing necessary to implement the technology for a soon-to-be built facility that will use the technology to produce hydromulch.</p>	<p>The CRADA for this project was transferred from Summit Seed, Inc. in Manteno, Illinois, to Leggett & Platt, Inc. in Carthage, Missouri.</p>	<p>A hydromulch facility could result in a revenue stream of \$20 to \$30 per ton to cotton gins within the region of the plant. Value-added processing has resulted in a paradigm shift from thinking of gin byproducts as waste to considering the material as a revenue stream.</p>
<p>Seedcotton moisture measurement system, "SMMS", is one application of broader technology that was developed by the scientists at Lubbock, Texas. This technology has produced three U.S. patents.</p>	<p>A material transfer agreement was completed with Cherokee Fabrication, 2008, to effectively implement the technology transfer to industry.</p>	<p>Cherokee Fabrication</p>	<p>As developed, the SMMS is capable of being utilized in both seed cotton moisture sensing as well as cotton bale lint moisture sensing.</p>

Measure 2.1.2 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

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

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

During FY 2010, ARS will

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

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

During FY 2011, ARS will

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

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

OBJECTIVE 2.2: INCREASE THE EFFICIENCY OF DOMESTIC AGRICULTURAL PRODUCTION AND MARKETING SYSTEMS

Fundamental to the long-term sustainability of agricultural production is the maintenance of an efficient, profitable, and economically competitive operation. Intense competition in global markets and pressure on U.S. farm policy to reduce price supports continue to emphasize the need for American agriculture to pursue and market higher value agricultural products. Furthermore, U.S. agricultural production and marketability is constantly influenced by factors such as unpredictable weather, disease and pest outbreaks, and changing consumer demands. Research must respond to consumer demands for healthy and safe products to ensure a sustainable and profitable agricultural production system that capitalizes on an abundant source of raw material for value-added food, fiber, and industrial products. The resulting technologies must effectively differentiate U.S. agricultural products from competing sources and provide customers with value-added processes that enhance product quality and value.

ARS research programs work to develop and transfer technology and information that make up the centerpieces of an efficient and economically sustainable agricultural sector. To improve the value and production efficiency of American crops and crop production, ARS takes responsibility for maintaining genetically diverse germplasm resource collections, which protects our genetic resource base and aids in plant and animal genetic research. In addition, ARS develops and disseminates science-based information to help U.S. agricultural producers manage unforeseen risks from climate, weather, pests, and disease outbreaks. Through these activities, ARS works to improve production efficiency and productivity to maintain profitability while enhancing the natural resource base upon which agriculture depends.

Key Outcome: Information and technology producers can use to compete more economically in the market place.

Performance Measures

Measure 2.2.1 Develop systems and technologies to reduce production costs and risks while enhancing natural resource quality.

Baseline 2006

Twelve new technologies and systems developed and used by customers to reduce the cost and increase profitability, improve the efficiency, or increase yield, and increase the sustainability of production.

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Target 2011

Cumulatively, 29 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.

Indicator 1

During FY 2008, ARS will develop new production practices and decision support tools that increase profitability and improve environmental quality.

FY 2008 Accomplishments:

1. Irrigator Pro was released as part of a collection of software called FarmSuite update 5.0. Irrigator Pro irrigation management system software is an irrigation manager developed by ARS researchers at Dawson, GA for peanut, cotton, and corn production.

Impact: Irrigator Pro helps growers reduce water consumption and pesticide applications, and increase the yield and profitability of corn, cotton and peanut crops. 750 copies of Irrigator Pro have been distributed through the Georgia Soil and Water Conservation Commission and directly to producers and crop consultants in Georgia, Florida, and Alabama. Adoption has exceeded expectations with Irrigator Pro being used to manage 42,000 of peanuts, 38,000 acres of corn, and 22,500 acres of cotton during 2008.

Measure 2.2.1 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, 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	Describe the Transfer	Identify the Customer	Impact
Combined winter grazing with non-inversion direct-seeding system that increases grower profitability while maintaining environmental quality.	ARS scientists at Watkinsville, GA and Auburn, AL documented the economic and environmental benefits of combining winter cattle grazing with direct-seeded summer row crop production.	Farmers in the southeastern U.S. who can combine winter cattle grazing with summer row crop production.	Combined winter cattle grazing with summer row crop production can generate additional income without causing increased soil compaction or reduced soil carbon amounts. When a special non-inversion shanks were used with direct seeding, spring planting reduced soil compaction, increased infiltration 83%, and increased soil carbon 38% near the soil surface. Combined with

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			\$75/acre/year greater net returns due to 7% higher cotton yields, this integrated grazing and non-inversion no-tillage conservation system proved successful not only for improving soil quality, but also for increasing farmer profits.
Swath-grazing-in-winter incorporated with crop production to increase Northern Great Plains farm income and environmental quality.	Presentations of the documented economic and environmental benefits of combining winter swath grazing by cattle for Northern Great Plains farms were made at farmer workshops and field days.	Northern Great Plains farmers who combine crop production with winter cattle feeding.	ARS scientists at Mandan, North Dakota showed by managing crop residues for livestock grazing in winter can save more than \$4,000 per 200 cows in feed costs a year, save labor costs, and provide an efficient way to recycle manure across fields that reduces fertilizer need. Combined with no-till and annual crop rotations, swath grazing gave farmers higher yields, more protection against drought, less soil erosion, and more efficient use of precipitation. The need for nitrogen fertilizer can also be cut in half by planting legumes like clover and using nutrients in manure more efficiently.
Economic organic grain production strategy for Mid-Atlantic region farmers.	Workshop and conference presentations.	Small-scale and women farmers in the mid-Atlantic region attending the Stewardship Conference in Hagerstown, MD; minority and disadvantaged farmers from Virginia and North Carolina at a conference held at Virginia State University in Petersburg; and two workshops and one field day in Libertytown, MD; Queen Anne's County, MD; and Beltsville, MD.	Based on a long-term farming systems project, ARS scientists at Beltsville, MD showed that returns from organic grain production systems were two-to-four-times greater than for conventional production. The greater economic returns were due to not only the higher organic price premiums paid, but also due to reduced weed competition that resulted from decreased seed number in soil from increased rotation diversity and crop rotation length. During favorable years, corn yield losses due to weeds were less than 5% in the longest organic rotation, a level similar to that achieved using herbicides in conventional no-till and chisel-till systems. Also, economic risk was decreased substantially when perennial forage such as alfalfa was included in an organic grain crop

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<p>Economic method developed to reduce the costs of incorporating cover crops into Midwest corn and soybean production systems.</p>	<p>ARS scientists in Ames, Iowa developed a dependable way to allow winter cover crops to self-seed in a soybean-corn rotation system, and winter cereal rye grown alone in a corn silage-soybean rotation. Winter cereal rye planted after corn silage harvest produced substantial biomass, had no impact on soybean yield, and had minimal potential increased risk to corn silage yields.</p>	<p>Ten presentations at grower meetings and six grower and USDA-NRCS grower field days. A total of 420 conventional and organic growers have viewed the technology.</p>	<p>rotation. These findings show that with good management, longer organic crop rotations can adequately control weeds in organic grain production systems, and that this strategy should be of value to conventional producers to reduce the amounts of herbicides that are required for their conditions.</p>
			<p>The results of these studies show that self-seeding winter cover crops do not require excessive seed production and thus may increase their adoption by growers if efficient seed dispersal technologies are developed so minimal purchased cover crop seed is required. Lower establishment costs may encourage conventional growers to use winter cover crops and experience the resulting environmental benefits in their fields.</p>

Measure 2.2.1 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

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

During FY 2010, ARS will

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

During FY 2011, ARS will

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

Measure 2.2.2 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.

Baseline 2006

Ten 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.

Target 2011

Cumulatively, 35 new technologies developed and used by ARS customers.

Indicator 1

During FY 2008, ARS will identify underlying genetic and physiologic mechanisms impacting reproductive efficiency, nutrient conversion, and growth in food animals.

FY 2008 Accomplishments:

1. Because feed efficiency is a time consuming and expensive trait to measure, genetic markers of feed efficiency in cattle could greatly enhance selection for this trait. A study was completed in growing steers to identify changes in liver gene expression associated with increased feed conversion efficiency during feed restriction and compensatory weight gain. The electron transporter activity in the mitochondria was up regulated during improved feed efficiency. Mitochondrial complex genes will be targets of further characterization because these genes have been associated with increased feed efficiency in poultry and cattle, and with quantitative trait loci for feed efficiency in cattle. These results will lead to definition of markers to improve selection for feed efficiency in cattle.

Impact: Determining the sources of genetic variation in feed efficiency could greatly enhance rate of progress to improve feed efficiency. Mitochondrial complex genes have been identified as good candidates for follow up research.

2. Genome research in cattle has been hampered by the lack of data on the expression of genes in normal tissues. In-depth data on gene expression of 95 normal cattle tissues using “next generation” sequencing technology was collected, and used to create an interactive database permitting a view of gene expression across tissues, tissue types, and tissue functions (e.g., immune tissues, neurological tissues, etc).

Impact: This research suggests methods to reduce both feed cost and nitrogenous waste released into the environment.

3. Current diets for rainbow trout may be over formulated with protein to meet individual amino acid requirements. ARS scientists found that when diets are formulated with regard to amino acid availability, instead of crude protein, growth rate can be maintained and total dietary protein can be reduced. Individual amino acids were supplemented to provide a better amino acid balance than that currently suggested in the literature. Supplementing with synthetic lysine, methionine and threonine reduced total dietary protein by 11% and increased protein retained as growth by 35%.

Impact: This research suggests methods to reduce both feed cost and nitrogenous waste released into the environment.

Indicator 2

During FY 2008, ARS will develop technologies leading to improved marketability of animal products.

FY 2008 Accomplishments:

1. The effect of early weaning beef calves at 90 days of age compared to normal weaning at 250 days of age was investigated. Previous research indicated that early weaning prior to shipment can reduce transportation stress and can increase subsequent performance in the feedlot. These data suggest that coincident weaning and transport stresses may compromise the immune system of calves, thus hindering subsequent performance and health. This study was conducted to determine if the innate immune response of early weaned calves differed from normal weaned calves in response to an immune challenge. Eighteen Brahman x Angus calves were fitted with an indwelling jugular catheters and blood sampled for 10 hours to determine serum concentrations of stress hormones, pro-inflammatory cytokines and acute phase proteins. Based upon these data, the innate immune system of early weaned calves appears to be less naïve than that of normal weaned calves, therefore making them more effective at recognizing and eliminating endotoxin from their body.

Impact: Early weaned calves show improved health in the feedlot. These data indicate that an altered innate immune system may be responsible for the improved feedlot performance previously reported in early weaned calves.

2. The fat content and composition of beef has received considerable interest in view of its implications for human health and meat quality characteristics. While unsaturated fats are beneficial when consumed in moderation, high levels of saturated fat are associated with increased serum low-density lipoprotein cholesterol concentrations and pose a risk factor for coronary heart disease. In addition, beef with the most desirable flavor has a higher percentage of monounsaturated fatty acids. Scientists have discovered a QTL with large effects on the fatty acid composition of beef and preliminary results suggest the myostatin locus may be causative.

Impact: The results guide future research to provide a clearer understanding of genetic mechanisms controlling palatability and healthfulness of beef and should ultimately lead to tools for producing beef of greater value to consumers.

3. Early-life stage (fry) survival of catfish is variable and low survival often cannot be attributed to diseases or malnourishment. Catfish fry are produced in hatcheries where eggs are hatched and fry are grown for 4 to 10 days. Fry are then transferred quickly from the hatchery to nursery ponds for further growth. Hatchery water and nursery pond water may have very different pH. It was found that catfish fry have high tolerance for sudden decreases in water

pH, but low tolerance for increasing water pH. A sudden increase of only 0.7 pH units can cause 10% loss of fry and an increase of 1.4 pH units will cause 50% mortality.

Impact: Farmers have been advised to monitor pH before stocking fry in nursery ponds and stock only when water pH in the nursery pond closely matches water pH in the hatchery. This simple practice has been widely adopted and will have significant impacts on fry survival in catfish farming.

4. As a result of bacterial outbreaks and poor water quality conditions in 2005 and 2006, mass mortalities of larval and juvenile oysters occurred in the industry and in the research hatchery at the Hatfield Marine Science Center. An improved water treatment system that includes filtration, UV sterilization, foam fractionation, and biological conditioning was developed.

Impact: Although optimization of the protocols remains to be done, closure of a key commercial hatchery was avoided when the hatchery operator replicated and scaled up the systems, resulting in dramatic improvement that partially restored production.

5. Intensive aquaculture systems utilize solids capture mechanisms such as settling basins and microscreen filters to remove uneaten feed, feces, and biofloc from fish culture water. Although effective in solids removal from fish production systems, backwashing of these mechanisms produces a waste stream that still contains too much water to be cost-competitive for most traditional disposal methods. Three technologies: gravity thickening settlers (i.e., settling cones), belt filters, and geotextile bag filters were evaluated and compared. The belt filter produced the cleanest discharge and highest treatment efficiencies, but its operation was more complicated and time consuming than the other processes.

Impact: This research identifies better waste management technologies and practices that can be implemented to improve waste capture, dewatering, and disposal of waste at aquaculture facilities.

Indicator 3

During FY 2008, ARS will identify genes and their function leading to DNA tests for use in food animal genetic improvement programs.

FY 2008 Accomplishments:

1. Modern vaccines have reduced productivity loss to viral diseases, however, many viral diseases continue to decrease animal productivity and welfare. Additional tools to complement vaccine control methods could aid in further reducing the negative effects of viral disease. Recently, a system known as RNA interference or RNAi has been developed that reduces the expression of specific genes. Scientists at the Avian Disease Oncology Laboratory in Michigan have adapted this technology to reduce the severity of viral infections in chickens by targeting virus genes.

Impact: The feasibility of this approach was shown in live birds where Marek's disease virus replication and pathogenesis has been reduced. This method has the potential to inhibit any infectious disease and may offer a valuable tool to control disease.

2. The quality and palatability of fresh retail pork is variable and tenderness is a key factor guiding consumer choices for pork. The ability to selectively breed for animals that are superior and consistent for meat quality traits would improve consumer acceptance and benefit the pork industry. A quantitative trait locus (QTL) region has been identified for pork tenderness around the calpastatin gene. Three markers in the calpastatin gene were highly

significantly associated with slice shear force, a measure of tenderness, in Duroc-Landrace and Duroc-Landrace-Large White populations.

Impact: These results provide publicly available genetic markers associated with slice shear force that may be useful to the swine industry for marker assisted selection of animals with superior tenderness.

3. Fish selected for one generation for resistance to the most important bacterial disease affecting trout culture, Bacterial Coldwater Disease, were evaluated. Bacterial coldwater disease is caused by the bacterium, *Flavobacterium psychrophilum* (Fp). Estimates on the genetic determination, heritability, of growth measured in the disease resistant line of indicate high heritabilities for 5-, 7-, 9-, and 12-month body weights, in addition to moderate heritability for Fp resistance, and significant genetic gain in disease resistance from one generation of selection. In addition, estimates of genetic correlations indicate that body weight traits and Fp resistance can be improved simultaneously.

Impact: This work will offer growers a fish more resistant to disease, without sacrificing growth performance.

4. In order to better define why some families of catfish are more resistant than others to experimental challenges with *Edwardsiella ictaluri*, the causative agent of enteric septicemia of catfish (ESC), a standardized screening protocol to distinguish between families with high or low levels of susceptibility was developed. Resistant families repeatedly demonstrate <30% mortality following experimental challenge, while susceptible families demonstrate >70% mortality. Analysis of gene expression in tissues from infected and non-infected fish following experimental challenge showed that a gene called *hepcidin* is differentially expressed in the two family types, showing a significantly higher expression in liver tissue at 24 hours post-challenge and at 72 hours post-challenge in spleen tissue.

Impact: Hecpudin has been identified as a key gene in resistance to ESC. Expression of hepcidin will be monitored in further experiments to determine its correlation with resistance to *E. ictaluri* and other pathogens.

Indicator 4

During FY 2008, ARS will 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.

FY 2008 Accomplishments:

1. A research consortium led by the Animal Improvement Programs Laboratory (ARS-BARC), and including US Meat Animal Research Center (ARS-NPA), University of Missouri, Illumina, Inc., National Association of Animal Breeders (a trade group representing cattle artificial insemination organizations in N.A.), INRA (France), and Merial, Inc. developed, tested, and commercialized a genome-wide bovine single nucleotide polymorphism (SNP) beadchip that assays the allele content at approximately 58,000 genome locations. Genotypes for over 10,000 cattle were generated on this SNP chip. Some of these genotypes were used to develop a whole genome selection (WGS) algorithm that produced genome enhanced predictions of genetic merit for three major dairy breeds. Over 3,000 genomic DNA samples were extracted from semen to support this work.

Impact: The initial success of WGS to enhance selection in Holsteins led to release of unofficial genome enhanced genetic predictions in April 2008. Predictions based on WGS will greatly reduce the cost of identifying top dairy bulls, and speed genetic progress. Genome enhanced evaluations are now provided quarterly to the NAAB.

2. The swine linkage map is based on over 3400 markers, developed primarily by scientist at the US Meat Animal Research Center in Clay Center, Nebraska. The Swine Genome Sequencing Consortium assembled 172 large fragments, from over 260,000 pieces, covering approximately 98% of the pig genome into a BAC physical map. Several computational methods were utilized to create thousands of links between the linkage and physical maps. Furthermore, comparing the porcine physical map to the human genome, the continuity and local ordering of segments of the porcine genome were improved. Some pig chromosomes are well mapped with few gaps remaining, while others consist of many fragments.

Impact: The map is publicly accessible on the internet (http://pre.ensembl.org/Sus_scrofa/index.html). This physical map is providing a framework for the generation and assembly of the pig genome sequence. Furthermore, the map is immediately useful to the pig research community to direct marker development, identify genes and fine map quantitative trait loci.

3. The development of tools for genomic research in rainbow trout will facilitate our ability to identify genes affecting phenotypes of economic importance in trout culture. Recently, scientists at the National Center for Cool and Cold Water Aquaculture in Leetown, West Virginia constructed a physical map of the rainbow trout genome which includes two billion base pairs of DNA and represents 75% - 80% of the genome.

Impact: This resource will facilitate genetic improvement by enabling identification of genes which affect important aquaculture production traits such as disease resistance.

Indicator 5

During FY 2008, ARS will continue to characterize germplasm of food animals for traits of importance.

FY 2008 Accomplishments:

1. Beef cattle breed associations produce expected progeny differences (EPD) as a measure of the genetic merit of individual bulls and cows for several economically relevant traits. However, these EPD are not directly comparable among different breeds. To address this problem, across-breed EPD adjustment factors were calculated on 16 breeds for growth traits (birth, weaning, and yearling weights and maternal milk) and on 8 breeds for carcass traits (ribeye area, backfat depth, and marbling) using data from the US Meat Animal Research Center Germplasm Evaluation program and EPD from breed associations. These adjustment factors were presented and released at the Beef Improvement Federation meeting to a North American audience, followed by publication on various websites and in the popular press.

Impact: This research allows producers to more effectively use available genetic resources and thereby more rapidly improve production of lean beef and meat quality.

2. U.S. salmon production is constrained by lack of genetic improvement, disease, low production efficiency and mandatory stocking of 100 percent native North American salmon. An applied Atlantic salmon breeding program to increase efficiency and sustainability of Atlantic salmon culture was initiated in 2003 when pedigreed families were obtained from two

St. John's River sources, Penobscot River, Gaspé, and landlocked salmon stocks. Smolts were stocked into sea cages in June 2005, harvested in February 2007, and evaluated for carcass weight, sex, and stage of sexual maturity. Overall St. John's River fish had the fastest growth with a carcass weight >4.1 kg compared to the slowest growth in landlocked fish at 1.7 kg.

Impact: Data were used to calculate breeding values on sibling adult brood fish and a line selected for carcass weight was produced in the fall of 2007; in addition approximately 500,000 eggs from these fish were released to industry. The North American Atlantic salmon industry continues to grow and a processing plant, closed in 2005, was reopened in Machiasport, Maine.

3. The US Rainbow Trout industry wants to be able to easily produce 100% sterile triploids for improved growth performance and germplasm protection. One strategy is to develop tetraploid animals to cross with diploids. However, current procedures for tetraploid induction are unreliable and labor intensive because of variability in the time at which induction treatment must be applied. Factors contributing to this variability were investigated and a strong influence of rearing environment was found. By maintaining broodfish in a common environment, a single time point for the application of pressure can be used to induce tetraploidy in eggs of fish from diverse genetic backgrounds.

Impact: New methods for sampling up to 20 fish simultaneously for verification of tetraploid induction were established. These results support procedures for induction of tetraploidy that are amply efficient for commercial implementation.

Indicator 6

During FY 2008, ARS will develop improved cryopreservation technology for storage of animal germplasm and continue to increase the stocks of germplasm stored within the National Animal Germplasm Program repository.

FY 2008 Accomplishments:

1. Use of cryopreserved semen in swine has been hampered by the poor performance of frozen-thawed semen which results in farrowing rates of 55% and 8 piglets/litter, which is 20-30 percentage lower and 2-3 fewer pigs per litter than expected with non-frozen semen. New protocols were developed where females' time of ovulation was manipulated, and a single insemination of thawed boar semen was timed to have fertile sperm at the site of fertilization 0-4 hours before the expected time of ovulation. With this new protocol litter size was about 96% of that using non-frozen semen; while the farrowing rate (80%) was equal to that using non-frozen semen in conjunction with standard industry breeding procedures.

Impact: These results show that, with proper treatment of recipient females, frozen-thawed boar semen can be used by swine producers to obtain fertility that is greatly improved over traditional procedures.

2. Knowing the quantity of germplasm necessary to reconstitute a population is one requirement for genebanks to use in setting goals for germplasm collections. FAO has recommended that to secure a chicken breed, at 150% of reconstitution needs, genebanks have 2,454 straws (0.5 ml) of semen. ARS scientists evaluated inseminating hens intramagnally vs. intravaginally and found the intramagnal procedure was significantly better. Additionally, econometric procedures were used to evaluate the maximum efficiency and duration by

which fertile eggs could be obtained from a single insemination. These results showed that maximum efficiency occurred at day 8 and fertile eggs could be harvested until day 17.

Impact: These findings significantly impact the development of germplasm collections for chickens. By using intramaginal insemination, rather than intravaginal insemination the number of units of germplasm required to secure a breed can be reduced from 2,454 to 386. The impact of this finding is that collections of germplasm from chicken breeds can be secured more rapidly at a lower cost of collection and a lower storage cost.

Measure 2.2.2 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS reported on five technological breakthroughs or scientific advancements that made significant contributions toward developing 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.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Feed efficiency in beef cattle	Oral presentations, webinars	Multiple corporations, government agencies and universities	Provided the industry results on the development genetic selection tools for feed efficiency in beef cattle and its economic impact on producer profitability
Early weaning can alter the immune response in beef cattle.	Oral presentation, scientific publications	Other scientists, beef producers, and feedlot owners	This knowledge provides progressive beef producers and feedlot owners alternative management practices to enhance beef production and animal well-being.
Whole genome SNP assay for determining genetic merit	Oral presentations, Scientific publications, Popular press publications, Product development by industry	Multiple germplasm companies, Genetic improvement corporations, Government, university and industry scientists	At industry request release of unofficial genome enhanced genetic predictions in April 2008. Genome enhanced evaluations are now provided quarterly to the National Association of Animal Breeders
Development of the swine linkage map	Web-site with linkage map publicly available, oral presentations, scientific publications	Swine breeding companies, Government, university and industry scientists	This map provides a framework for generation and assembly of the pig genome sequence. Also, the map is immediately useful to the pig research community to direct marker development, identify genes and fine map quantitative trait loci

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Atlantic salmon germplasm transfer to industry	Provision of fertilized eggs of certified North American Atlantic salmon stocks	U.S. salmon farming company through Maine Aquaculture Association	Due to the listing of Atlantic salmon as endangered, the East Coast salmon farming industry is required to grow fish of North American origin. The ARS lab is transferring germplasm of certified North American to US farms
Inhibition of viral disease in chickens through use of RNA interference	Scientific publications, oral presentations	Chicken producers, Animal health companies, Other scientists	This technology has the potential to inhibit any infectious disease and may offer a valuable tool to control disease
New catfish incubator design	Oral presentations	Catfish fry producers	This equipment will allow hatchery operators to hatch 4x more with the same water use. Stakeholder testing equipment on commercial scale.

Measure 2.2.2 Outyear Performance Plan (the future performance indicators for this Measure)

During 2009, ARS will

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

develop technologies leading to improved marketability of animal products.

identify genes and their function leading to DNA tests for use in food animal genetic improvement programs.

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.

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

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

During 2010, ARS will

identify underlying genetic and physiologic mechanisms for traits impacting efficiency of nutrient utilization, reproduction, adaptability, health and well-being in food animals.

develop genomics infrastructure and tools to efficiently identify genes and their function for exploitation in genome-enabled improvement and precision management of food animal species

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

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characterize nutrient requirements of fish and shellfish, measure nutrient availability of feedstuffs to develop nutritional strategies for improving dietary efficiency, and to meet the need for sustainable sources of feedstuffs and the requirements of fish and shellfish with superior growth rates.

During 2011, ARS will

identify underlying genetic and physiologic mechanisms for traits impacting efficiency of nutrient utilization, reproduction, adaptability, health and well-being in food animals.

develop genomics infrastructure and tools to efficiently identify genes and their function for exploitation in genome-enabled improvement and precision management of food animal species

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

characterize nutrient requirements of fish and shellfish, measure nutrient availability of feedstuffs to develop nutritional strategies for improving dietary efficiency, and to meet the need for sustainable sources of feedstuffs and the requirements of fish and shellfish with superior growth rates.

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 the Nation's crops.

Baseline 2006

Ten new technologies developed and used by ARS customers to increase production efficiency and enhance the economic value and quality of U.S. crop production while decreasing the environmental footprint of production systems.

Target 2011

Cumulatively, 35 new technologies developed and used by ARS customers.

Indicator 1

During FY 2008, 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, feed, and flower supply that is competitive in the global marketplace.

FY 2008 Accomplishments:

1. Wheat and barley stripe rust has caused major yield reductions and economic losses for grain producers in the Pacific Northwest, Midwest, and eastern United States since 2000. ARS scientists have partnered with regional wheat and barley breeders to identify new sources of stripe rust resistance and develop DNA markers linked to resistance genes.

Impact: ARS genotyping scientists and variety trial coordinators have facilitated genetic selection and field disease trials. ARS and university geneticists, through the Wheat and Barley Stripe Rust Initiative, have released in 2008 new wheat and barley varieties with significantly improved stripe rust resistance in all affected regions of the United States.

2. Legume production, especially of dry pea, has increased dramatically in the north central United States. Fusarium root rot is a devastating disease of both vegetable and dry peas in the United States, especially in summer rainfall areas. ARS scientists released three new pea germplasm lines (W6 26740, W6 26743 and W6 26745) with improved agronomic qualities and high levels of resistance to Fusarium root rot for immediate use by breeders for cultivar improvement.

Impact: These materials will accelerate development of commercial peas with innate resistance to Fusarium root rot, thereby enhancing yield and reducing the need for chemical application.

3. Although the effects of elevated CO₂ and O₃ on leaf expansion have been studied individually, few studies examine leaf expansion in more realistic simulations of future conditions, with simultaneously elevated CO₂ and O₃. ARS researchers examined leaf growth and expansion in soybean and aspen exposed to elevated CO₂ and elevated O₃ in a field setting to determine how leaf growth parameters are altered by climate change. Leaves were larger upon unfolding in elevated CO₂ and smaller in elevated O₃, which compounded over time to alter final leaf area, even though relative growth rates were similar.

Impact: These results, suggest that leaf growth is altered by CO₂ and O₃ very early on in growth, contrary to previous findings that only fully expanded, older leaves are sensitive to O₃. This information provides clues as to how soybean yield can be optimized and help breeders select soybeans that yield better under climate change.

4. Equations and models exist that can separately determine plant growth and development as influenced by temperature and light as well as the energy balance and needs of greenhouses in certain environments. However, no single model combines these calculations so that a user can easily determine how a greenhouse environment might be managed to optimize for energy use, cost, and crop development. ARS scientists combined their previously released Virtual Grower software, which was developed to calculate energy use for different greenhouse styles in 230 US locations, with 12 plant growth and development equations so that the influence of one factor (cost of heating a greenhouse) can be seen on another (crop production).

Impact: This has enabled crop production optimization unique to a grower's facility and location, improved estimates of the cost of production, and increased awareness of how one optimization strategy can influence another. The improved model has been downloaded and distributed over 500 times at no charge all over the world since its release in January 2008.

5. The Varroa mite (*Varroa destructor*) is a worldwide threat to honey bees and options to control them are limited. Plant essential oils show promise as acaricides against the Varroa mite, but the delivery of these compounds remains a challenge due to the low water solubility and high volatility. A technique to microencapsulate essential oils in beta cyclodextrin complexes was developed by ARS scientists that led to the detection of high levels of the essential oils in bee tissues without any imposed toxicity to the bees.

Impact: The encapsulation technique can be used as a delivery system for many different compounds that deter feeding and reproduction of Varroa.

6. Use of traditional settings in air blast sprayers in nursery applications resulted in excessive spray deposition inside tree canopies and loss of spray mixtures to the ground and air. Adoption by nursery growers of new recommendations based on half-rate application of pesticides with various adjustments of air-assisted sprayers developed by ARS scientists have resulted in half the usage of pesticides for pest and disease controls in nursery shade tree plants.

Impact: By using the half-rate technology, growers reduced pesticide applications and reported savings of over \$200-\$500 per acre.

7. Cane berry producers have sought ways to lessen their dependence on honeybees for pollination because they are often relatively small growers without access to migratory beekeepers. A manageable native bee in the genus *Osmia* (it has no common name) has been identified by ARS scientists as a good berry pollinator, and ARS has now developed methods to successfully use this bee for commercial cane berry pollination, including methods to increase its population levels, completing 5 years of successful field testing and modification.

Impact: This bee is now being used by some Oregon farms, and is being tried in California. Populations are being increased 2 to 3-fold per year in commercial berry fields using nesting materials that are readily available to growers.

8. Resveratrol is a plant compound that has been shown to have anti-cancer, anti-inflammatory, blood-sugar-lowering, and other beneficial cardiovascular effects. Strawberries contain two forms of resveratrol. ARS scientists determined that genotype variation, degree of ripeness, compost, mulch, atmospheric carbon dioxide concentration, growth temperature, and growth regulator treatment all affect resveratrol content.

Impact: This research suggests that both genetic background and cultural practices have potential to influence antioxidant capacity in crops.

Indicator 2

During FY 2008, ARS will maintain and enhance genetic and genomic databases and make information accessible via standard software from the Internet.

FY 2008 Accomplishments:

1. Supported by ARS funding and by a \$1.4 million, 3-year grant from the Global Crop Diversity Trust, ARS researchers, in cooperation with Bioversity International, are developing a new, leading-edge version of the Germplasm Resources Information Network (GRIN), which currently manages information for the U. S. and Canadian national plant germplasm systems. When complete, the new scalable and modular "GRIN-Global" database system can be readily implemented by any genebank—even in the developing world.

Impact: The source code will be freely distributed so key documentation for the world's plant germplasm collections will be more secure, and germplasm will be more readily accessible to crop breeders and researchers world-wide.

2. To better understand and manipulate plant development and important economic traits, it is essential to identify the coordinated induction or repression of numerous genes that are involved in various biochemical pathways. In collaboration with the University of Illinois, ARS researchers developed an apple microchip consisting of 40,000 gene probes that can be used to better understand which genes and which biochemical pathways are involved in such things as growth, fruiting, fruit quality, disease and stress resistance, etc.

Impact: This tool will allow scientists to study the genetic regulation of traits important to the apple industry and will also be able to be used for pear, peach, plum, apricot, and other Rosaceous plant species.

3. Reliable DNA markers for genetic mapping in blackberry are needed. ARS scientists, in collaboration with scientists at Clemson University, sequenced 2,678 blackberry genes, from which 673 molecular markers were developed.

Impact: These are the first blackberry gene sequences and markers to be made publicly available. This work lays the foundation for use of these markers by other scientists in genetic studies on blackberry.

Indicator 3

During FY 2008, ARS will describe in model plants and crop plants the structure, function, and regulation of agriculturally important genes that control plant composition and yield.

FY 2008 Accomplishments:

1. Dietary vitamin A deficiency causes eye problems in 40 million children throughout the world each year, and puts an additional 140-250 million at risk for related vitamin A deficiency disorders and increased mortality. Breeding to increase levels of provitamin A (biofortification) using existing natural genetic variation in corn is an economical and helpful approach to address this challenge, particularly where children subsist on largely corn-based diets. In collaboration with Cornell and University of Illinois researchers, ARS scientists have identified a major gene that determines the levels of provitamin A in corn. Natural genetic variants of this gene can increase provitamin A content five-fold.

Impact: Inexpensive markers for the gene were developed that enable crop breeders to genetically select for higher provitamin A content; the markers are now being applied in corn genetic improvement programs in developing countries.

2. Soybean seeds contain allergens that have undesirable consequences when soy products are consumed by people or animals. Previous research led to the discovery of germplasm accessions from the USDA-ARS soybean germplasm collection with low levels of the major allergen, P34. ARS scientists successfully characterized P34 gene sequences from different soybean accessions and discovered the mutation responsible for the low allergen trait. Molecular marker assays were developed for direct selection of the low allergen trait.

Impact: Low-allergen soybean varieties can now be developed rapidly by the use of the molecular markers in breeding programs. This technology has been released to the public to enable crop breeders to develop allergen-free soybeans.

3. Genes that control plant structure and architecture affect important agricultural traits including yield and biomass. ARS scientists have elucidated a genetic pathway controlling plant structure in the model plant *Arabidopsis*. Specific genes in the regulatory pathway have been identified including an essential gene required for cell division and growth in plant seedlings.

Impact: The significance of this finding is that genetic manipulation of this gene can be exploited by plant breeders to improve crop yields and biomass for bioenergy.

Indicator 4

During FY 2008, ARS will improve plant genetic transformation systems to expand their utility and improve exploitation of genome sequence information to identify valuable genes in germplasm collections.

FY 2008 Accomplishments:

1. The genome of the transgenic papaya cultivar, 'Sunup', was sequenced by ARS scientists and their collaborators so as to better understand the genetic control for key papaya traits such as flowering and to provide information needed by Japan to consider deregulation of transgenic papaya fruit, which could expand Hawaii's export papaya market.

Impact: The resulting genomic information will accelerate elucidation of the genetic control for other key papaya traits.

2. Outbreaks of Asian soybean rust have now occurred in all major soybean-producing countries and can cause yield losses up to 75 percent. Thus far, only four resistance genes to Asian soybean rust have been identified. ARS scientists located and sequenced the chromosomal regions that include two of the resistance genes, finding that the regions contained 23 and 3 candidate resistance genes, respectively. Researchers are rapidly developing markers for those genes to enable more precise use by breeders. Significantly, those regions also confer resistance to other important soybean pathogens. Therefore, the markers developed for Asian soybean rust may also benefit research with other important soybean diseases. Furthermore, additional ARS scientists discovered a new genetic source for soybean rust resistance, confirmed that it is at the same chromosomal location as a currently known resistance gene, but found that it is a different form, or allele, of that gene.

Impact: This new allele increases the diversity of types of rust resistance in soybean varieties and, via closely linked DNA markers, the new resistance sources can be readily transferred to new varieties.

3. Genome sequencing of rice has identified thousands of genes, most of which with unknown functions. ARS researchers, working with scientists at the University of California, Davis, and with USDA CSREES support, have generated a large population of rice mutants with altered DNA sequences. Using this resource, rice mutants can be selected for any gene sequence of interest and characterized in the laboratory or field. The rice mutants, called "tilling" mutants, were added to the ARS rice genetics stock collection at Stuttgart, Arkansas, to be shared with interested researchers.

Impact: These new genetic resources enable researchers to evaluate and exploit the effects of altering any rice gene and may serve as the basis for new strategies to protect rice from disease and pests.

4. ARS scientists have identified a gene coding for a protein of a naturally occurring heat protection system of plant cells, and developed a method to use it to select transgenic plants. Transformed cells and plants survive a high temperature challenge, while non-transformed tissues do not. In additional research, ARS scientists have transformed wheat with linear DNA that only contains wheat DNA sequences needed for expression of new traits.

Impact: These new methods enable plant scientists to construct biotech wheat plants that only contain wheat DNA. These new methods eliminate the need to use antibiotic resistant genes as selectable markers for genetic transformation of plants.

Indicator 5

During FY 2008, ARS will develop new genetic and genomic methods and tools to identify specific genes that affect end-product traits desired by consumers, such as oil and grain quality, nutrient composition, disease resistance, and stress tolerance in agricultural crops.

FY 2008 Accomplishments:

1. ARS scientists have developed a new generation of soybean breeding lines with extremely valuable drought tolerance. In regional and local testing, two lines, N04-9646 and N01-11771, were slow wilting, with a substantial yield benefit when grown under dry conditions. Uncharacteristically, they also yielded reasonably well in environments with minimal plant stress. These long-awaited genetic materials, now available to and being used by commercial breeders as parental stock, are likely the most drought-tolerant soybean materials in the world.

Impact: The impact of these new lines on soybean production will be fully realized as commercial breeding programs release new cultivars derived from this ARS stock.

2. Sorghum, an important grain crop internationally and in the United States, required additional molecular tools to accelerate its genetic improvement. Much potentially valuable sorghum germplasm materials are of tropical origin and do not successfully flower and produce seed in the U.S. where day-length is much longer during the growing season. Through high resolution mapping, ARS scientists, in cooperation with scientists at Texas A&M University; MMR Genetics, LLC; and the Department of Private Industries and Fisheries, Queensland, Australia, identified candidates for the photoperiod sensitivity gene, *ma1*.

Impact: This accomplishment is important because it will enable more rapid exploitation of a wealth of previously unusable sorghum germplasm to develop higher-producing sorghum varieties for U.S. farmers.

3. While a number of ripening-associated genes have been isolated from tomato and other specialty crop species, few “master regulator” genes have been identified. ARS scientists have identified a new “master regulator” gene which impacts downstream ripening traits including accumulation of nutritionally important carotenoids and important quality attributes such as softening and ascorbate (vitamin C) accumulation. Regulatory analysis of this gene suggests that it operates independently of the ripening hormone ethylene and thus may be part of a biological process common to fruiting species that do not require ethylene for ripening (e.g. strawberry, grape, citrus).

Impact: This new gene has potential use for prolonging post-harvest shelf-life and improving texture and nutrient quality in fruit crop species.

4. The sugarbeet root maggot is one of the most devastating insect pests of sugarbeet that is found in two-thirds of all U. S. sugarbeet fields and accounts for 10-100 percent reduction in yields. ARS scientists have identified sugarbeet genes that are associated with root responses to root maggot feeding in both susceptible and moderately resistant sugarbeet varieties. One gene in particular was identified, cloned, reconstructed for over-expression in plants and introduced into a sugarbeet root model system and a model plant. Preliminary studies of insect resistance in the genetically engineered plants suggest that this gene increases insect resistance to a number of plant pests.

Impact: Plant scientists can use this new information to develop effective plant pest resistance mechanisms for sugar beets and other crop plants.

Indicator 6

During FY 2008, ARS will construct and maintain physical, genetic, and transcript maps to facilitate comparative analyses among plant genomes.

FY 2008 Accomplishments:

1. Curly top is a devastating viral disease that almost eliminated the sugarbeet industry in the western United States until resistant cultivars became available. ARS scientists in Kimberly, Idaho, identified genetic markers for genes that confer resistance to this disease in sugarbeets.

Impact: The results of this research can accelerate the breeding of new, superior sugarbeet cultivars resistant to curly top.

2. Before physical maps can be fully exploited to isolate and clone agronomically important genes, they must be integrated with genetic maps. ARS scientists succeeded in integrating the soybean physical map with the genetic map by identifying nearly 3,300 genetic markers for Bacterial Artificial Chromosome (BAC) clones comprising the physical map. Two-hundred sixty-five were polymorphic and were genetically mapped so as to further integrate the physical and genetic maps of soybean.

Impact: The integrated physical map is aiding in a high quality assembly of the whole-genome shotgun sequence of soybean, which will speed the completion of the project, and might ensure the success of future research relying on the assembly.

3. There are few publicly-available genetic markers for sugarbeet, table (red) beet, fodder beet, and chard, despite their importance in modern genetic analyses and potential for marker-assisted breeding of these important crops. Existing public genetic sequences were analyzed by ARS scientists and more than 2,500 potential markers were identified and tested for their utility.

Impact: More than 100 markers were mapped to a specific chromosomal location in the beet genome, increasing by an order of magnitude the number of genetic markers available for beet germplasm characterization and genetic analyses.

4. The genome of an organism contains all of the hereditary information encoded in the DNA and a number of crop genomes are now being sequenced. However, it is difficult to assemble DNA sequence information for entire crop plant genomes because there are many

repetitive DNA segments. ARS scientists, with support from the National Science Foundation and USDA-CSREES National Plant Genome Initiative, have developed new bioinformatic software called TEnest that will accelerate the assembly of crop genomes. This new tool has been applied to four agriculturally important grains including maize, barley, wheat, and rice.

Impact: This new bioinformatics tool dramatically increases the speed and efficiency with which genomes are assembled. This new information provides insight into the evolutionary history of the plant and enables crop breeders to rapidly identify potential new genes for genetic improvement.

Indicator 7

During FY 2008, ARS will identify, acquire, and expand plant germplasm collections so as to enhance their diversity.

FY 2008 Accomplishments:

1. During fiscal year (FY) 2008, the 20-plus genebanks in the USDA-ARS National Plant Germplasm System (NPGS) added more than 25,000 new samples, so that a total of more than 510,000 samples of more than 13,100 plant species are now conserved by NPGS genebanks. Scientific interest, especially for germplasm of specialty crops, has increased tangibly during the last few years, with the average number of samples distributed per year by the NPGS now totaling about 140,000 – 40,000 more than the average a decade ago.

Impact: These materials are keys for continued progress in crop genetics and breeding which is requisite for future food security.

Indicator 8

During FY 2008, ARS will strengthen evaluation and breeding programs for specialty crops that have increasing economic importance.

FY 2008 Accomplishments:

1. The strawberry industry in the Pacific Northwest has been dominated for more than 30 years by a single variety ('Totem') with excellent fruit quality, but which is becoming less economical to produce due to increasing disease problems, moderate yields, and medium fruit size that leads to high picking costs. ARS researchers developed new cultivars with excellent processed fruit quality and which are more efficient to harvest.

Impact: The ARS strawberry cultivar 'Tillamook' became the number one cultivar purchased by the commercial industry in the Pacific Northwest, the first time in over 3 decades that 'Totem' was not the number one cultivar sold. Another strawberry cultivar, 'Stolo', developed and released in cooperation with Agriculture and Agri-Foods Canada, is resistant to root weevils and may enable growers to produce strawberries with reduced inputs of insecticides.

2. Development of specialty potato varieties with enhanced culinary traits and nutritional profiles has attracted commercial interest, especially of small producers, who can market smaller quantities of potatoes in markets that pay considerably more per pound than the traditional markets. ARS researchers have identified and collected potatoes grown for hundreds of years by Native Americans and Native Alaskans, introduced these cultivars into tissue culture, eradicated viruses, and re-introduced them to the Native groups.

STRATEGIC GOAL 2

Impact: This has helped to preserve specialty potato varieties in the cultures of the tribes and increased enthusiasm for science education focused on their own heritage food items.

3. There is a need to identify genes that help plants grow and produce fruit under adverse weather conditions such as cold, heat, and drought. New sequences from approximately 10,000 genes expressed in strawberry under stress conditions were obtained this year by ARS researchers and made publicly available by deposition into GenBank. Analysis of all expressed gene sequences from strawberry that are currently in the public domain identified 13,449 unique gene sequences. These sequences represent the foundation for the genomic study of environmental stress on production of flowers and fruit in strawberry and other members of the Rosaceae family.

Impact: These sequences can be used by scientists for molecular marker development, for examining expression of genes in response to stress, and for testing the function of genes identified as potentially useful for increasing plant tolerance to environmental stresses.

Measure 2.2.3 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS reported on four 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 footprint of production systems.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
ARS scientists at Toledo, Ohio, combined their previously released Virtual Grower software, which was developed to calculate energy use for different greenhouse styles in 230 U.S. locations, with 12 plant growth and development equations, so that the influence of one cost (of heating a greenhouse) could be seen on another (that of crop production). This work has enabled growers to optimize crop production based on factors unique to their facility and location, improve production cost estimates, and increase their awareness of how one optimization strategy can influence another.	The software has been made available without charge through the Internet.	Greenhouse growers and researchers.	The improved model has been downloaded and distributed over 500 times to individuals all over the world since its release in January 2008.

STRATEGIC GOAL 2

<p>ARS researchers in the Pacific Northwest have identified and collected potatoes that have been grown for hundreds of years by Native Americans and Native Alaskans. They have introduced these cultivars to tissue culture, eradicated viruses, and re-introduced them to the Native groups.</p>	<p>ARS researchers took several thousand cuttings of potato to the Makah Nation for a Potato Day, with talks about science, nutrition, gardening, and politics of food production. In Alaska, "Maria's Potato" was re-introduced to the Tlingit village where it was originally grown years after it had disappeared.</p>	<p>Native American groups.</p>	<p>This has helped to preserve the place of these crops in the traditional culture of the tribes and increased enthusiasm for science education of their own heritage food items. In addition, the value-added element allows them to consider marketing smaller quantities in local markets that pay considerably more per pound than the mass commodity markets.</p>
<p>Molecular marker assays have been developed for low allergen soybeans. Previous research indicated that accessions from the ARS soybean germplasm collection contain low levels of the major allergen, P34. ARS scientists successfully characterized P34 gene sequences from different soybean accessions and discovered the mutation responsible for the low allergen trait, and subsequently developed molecular marker assays for its direct selection.</p>	<p>This technology has been released to breeders publicly for the development of allergen-free soybeans.</p>	<p>Soybean breeders and researchers.</p>	<p>As a result, breeding programs are able to use the molecular markers to rapidly develop low allergen soybean varieties.</p>
<p>ARS researchers developed a new strawberry – 'Tillamook' – for Pacific Northwest production systems that have excellent processed fruit quality and are more efficient to harvest. The strawberry industry in the Pacific Northwest has been dominated by a single variety – 'Totem' – for over 30 years, and while 'Totem' has excellent fruit quality, it is becoming less economical to produce due to increasing disease problems, moderate yields, and medium fruit size that leads to high picking costs.</p>	<p>Public release of germplasm.</p>	<p>Strawberry growers in the Pacific Northwest.</p>	<p>Over 6.3 million plants of 'Tillamook' were sold last year, making it the number one cultivar purchased by the commercial industry in the Pacific Northwest. This is the first time in over 3 decades that 'Totem' was not the number one cultivar sold.</p>

Measure 2.2.3 Outyear Performance Plan (the future performance indicators for this Measure)**During FY 2009, ARS will**

develop technologies and strategies to manage or mitigate pests, pathogens, weather damage, and/or improve crop quality to strengthen the U.S. agricultural production base and provide higher-value products.

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

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

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

develop new genetic and genomic 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.

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

identify, acquire, and expand plant germplasm collections to enhance their diversity.

strengthen evaluation and breeding programs for specialty crops that have increasing economic importance.

During FY 2010, ARS will

develop technologies and strategies to manage or mitigate pests, pathogens, weather damage, and/or improve crop quality to strengthen the U.S. agricultural production base and provide higher-value products.

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

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

exploit genome sequence information to identify valuable genes in germplasm collections.

develop new genetic and genomic 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.

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

identify, acquire, and expand plant germplasm collections to enhance their diversity.

strengthen evaluation and breeding programs for specialty crops that have increasing economic importance.

During FY 2011, ARS will

develop crop production strategies to optimize crop genetic potential and mitigate losses due to biotic and abiotic stresses.

develop new technologies to enhance the productivity of crop production by increasing the mechanization and automation options available to producers.

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

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

exploit genome sequence information to identify valuable genes in germplasm collections.

develop new genetic and genomic 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.

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

identify, acquire, and expand plant germplasm collections to enhance their diversity.

strengthen evaluation and breeding programs for specialty crops that have increasing economic importance.

OBJECTIVE 2.3: PROVIDE RISK MANAGEMENT AND FINANCIAL TOOLS TO FARMERS AND RANCHERS

Activities related to this objective are primarily carried out by other USDA agencies.

Strategic Goal 3:

Support Increased Economic Opportunities and Improved Quality of Life in Rural America

Programs and activities related to this goal are primarily carried out by other USDA agencies. However, ARS has a large and very positive impact on rural America. For example, the National Agricultural Library operates the [Rural Information Center \(RIC\)](#). The Center assists local communities by providing information and referral services to local, tribal, state, and Federal government officials; community organizations; libraries; businesses; and citizens working to maintain the vitality of America's rural areas. The RIC Web site contains over 3,000 links to sources of current and reliable information on a wide variety of rural resources and funding sources, including RIC's Database: [Federal Funding Sources for Rural Area Databases](#).

The Rural Information Center information and referral services include:

- Responding to a broad array of information requests on topics such as successful strategies, models, and case studies of community development projects; small business attraction, retention, and expansion; housing programs and services; tourism promotion and development; recycling programs and community water quality; and technology transfer to rural areas.
- Developing customized information products in response to specific inquiries (e.g., assistance in economic revitalization issues; local government planning projects; funding sources; technical assistance programs; research studies, etc.)

In addition, in support of the White House Initiative on Tribal Colleges and Universities (TCU), ARS provides opportunities to American Indian communities through Memoranda of Understanding, specific cooperative agreements, and various programs and activities. ARS helps to strengthen the management and administrative infrastructure of TCU libraries; provides facilities and equipment to the libraries; sponsors internships, fellowships, lectures, career fairs, workshops, and other learning and training opportunities for TCU students and faculty; and provides student tuition assistance. These outreach efforts are intended to improve the quality of life in Native American communities by ensuring their access to USDA sponsored programs.

However, in planning research, ARS organizes its research program around the other four programmatic USDA/ARS Strategic Plan goals. In conducting research to ensure the quality and safety of food and other agricultural products, assess the nutritional needs of Americans, sustain a competitive agricultural economy, and enhance the natural resource base and the environment, ARS helps to provide economic opportunities for rural citizens, communities, and society as a whole.

Strategic Goal 4:

Enhance Protection and Safety of the Nation's Agriculture and Food Supply

A secure and efficient agricultural production system is critical to providing the American consumer with a safe and healthy food supply. To maintain such a system, it is necessary to minimize production losses; maintain market viability; promote responsible environmental stewardship; and prevent, monitor, and control diseases that affect animals and humans. Diseases can negatively affect agricultural production systems by causing direct harm to livestock, threatening the health of agricultural workers and the public, and impacting trade.

ARS is an essential partner in ensuring the safety of the Nation's crop and animal products, producing the knowledge that the Nation needs to constantly improve and protect agricultural processes and products. As the agroecosystem evolves in response to changing conditions and human needs, ARS develops the knowledge to protect the Nation's agricultural supply from new threats presented by pathogens, parasites, environmental stresses, and arthropods. The Agency also participates in the development of new, practical technologies, and in the transfer of commercially viable concepts to industry. ARS research and technologies are used by many other Federal and private groups and action agencies, such as the Departments of Defense and Homeland Security, to protect the health of personnel, the integrity of property, and the environmental safety of logistic operations.

OBJECTIVE 4.1: PROVIDE THE SCIENTIFIC KNOWLEDGE TO REDUCE THE INCIDENCE OF FOODBORNE ILLNESSES IN THE U.S.

For the Nation to have safe and affordable food, the food system must be protected at each step from production to consumption. The production and distribution system for food in the United States encompasses a diverse, extensive, and easily accessible system that is open to the introduction of pathogens (bacteria, viruses and parasites), bacterial toxins, fungal toxins (mycotoxins), and chemical contaminants through natural processes, global commerce, and intentional means. In response to these threats, crop and livestock production systems must be protected during production, processing, and preparation from pathogens, toxins, and chemicals that cause disease in humans.

To ensure the security of production systems, ARS conducts basic, applied, and developmental research resulting in new technologies, new and improved management practices, pest management strategies, sustainable production systems, and methods of controlling potential contaminants. These ARS activities are key to providing a safe, plentiful, diverse, and affordable supply of food, fiber, and other agricultural products.

Key Outcome: Reduction in foodborne illness associated with the consumption of meat, poultry and egg products.

Performance Measure

Measure 4.1.1 Develop new technologies that assist ARS customers in detecting, identifying, and controlling foodborne diseases that affect human health.

Baseline 2005

Thirteen new technologies developed and used by ARS customers 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, APHIS, ERS, CDC, FDA, DHS, DoD, Risk Assessment Consortium, Codex Alimentarius Commission, and consumer and commodity organizations.

Target 2011

Cumulatively, 40 new technologies developed and used by ARS customers.

Indicator 1

During FY 2008, ARS will utilize 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.

FY 2008 Accomplishments:

1. Antibiotic resistant bacterial pathogens pose a serious threat to human and animal health. The bacterial strains that are resistant to multiple antibiotics (MR) frequently harbor plasmids (extra-chromosomal circular DNA) or other mobile genetic elements that carry the resistance genes that can be spread to non-resistant bacteria. It is necessary to assess the prevalence of such elements and understand the mechanisms of transmission. ARS scientists at Wyndmoor, Pennsylvania, examined four small plasmids conferring kanamycin resistance in Salmonella strains that cause human illness. These plasmids are closely related to each other and to other plasmids from E. coli and other pathogens that cause gastrointestinal illness, and they exist in moderately high abundance within bacterial cells. Their presence is not routinely assessed by typing methods used for characterization of the MR plasmids, thus the prevalence of this plasmid group may be underestimated.

Impact: This study underscored the value of continued surveillance of the emergence and spreading of MR strains by regulatory and public health agencies (CDC) and the importance of monitoring for the presence of this group of plasmids conferring resistance to kanamycin in Salmonella.

2. Shiga toxin producing E. coli (STEC) from cattle are known to cause disease in humans, however, it was unknown whether swine harbored similar pathogens. ARS scientists isolated and examined over 200 different STEC strains from swine feces to determine the presence of

genes involved in causing disease (virulence), resistance to antibiotics, and their acid tolerance. Results indicated that the strains possessed 22 different combinations of virulence genes, including genes found in *E. coli* strains that cause disease in humans and animals. The swine STEC bacteria displayed resistance to a number of antibiotics, and one strain was resistant to 15 antibiotics. The swine STEC strains were also found to be resistant to acids. This is critical since acid resistance plays a vital role in the survival of bacteria in acidic foods and in determining their infective dose in humans.

Impact: The study demonstrated that swine STEC are a heterogeneous group of organisms possessing important virulence genes that can potentially cause human illness. This information was critical for producers and regulatory agencies for the implementation of good production practices.

3. *Yersinia enterocolitica* is a major human foodborne pathogen and is one of the eight bacterial foodborne pathogens under FoodNet surveillance. Swine are the major animal reservoir for *Y. enterocolitica* strains, which are potentially pathogenic for humans. ARS scientists at Ames, Iowa, examined critical factors for *Y. enterocolitica* infection based on screening feces and tonsillar swabs of hogs on 122 premises. Four risk factors were identified and odds ratio (OR) for *Y. enterocolitica* infections were determined: location in a central state (OR = 0.3), vaccination for *E. coli* (OR = 3.0), percentage of deaths due to scours (OR = 3.5), and presence of meat/bone meal in grower-finisher diet (OR = 4.1).

Impact: This study was the first attempt to identify risk factors for *Y. enterocolitica* in the U.S. hog population, and is critical for swine producers and regulatory agencies such as USDA-APHIS.

4. Demand for corn has driven cattle producers to feed other available feedstuffs, such as wet distiller's grains with soluble's (WDGS). The use of WDGS in cattle diets has resulted in mixed results relative to *E. coli* O157:H7 in small studies, but long-term studies with large animal groups have not been performed. ARS scientists in Clay Center, Nebraska, utilizing 600 calf-fed steers in the feedlot environment, examined the level and prevalence for *Escherichia coli* O157:H7 on hides and in feces for 245 days through the growing and finishing phases of production. Feeding 14% WDGS (on dry matter basis) in the growing ration was associated with slightly higher prevalence for *E. coli* O157:H7 in the feces compared to animals fed no WDGS. In the finishing phase, animals that received 40% WDGS in their diet had greater prevalence of the pathogen on hides and in feces compared to 0% WDGS, but part of the difference in feces prevalence was associated with one pen of 40% WDGS-fed cattle.

Impact: The impact of the work for industry and regulatory agencies is that higher prevalence of *E. coli* O157:H7 associated with cattle fed high levels of WDGS could result in a greater pathogen load at time of slaughter

5. Numerous environmental stressors have been identified which may impact infection, prevalence, or levels of pathogens such as *Escherichia coli* O157:H7 that are shed by livestock. Over 2-year period ARS scientists in Clay Center, Nebraska, individually examined feedlot cattle for signs of heat stress on days when the temperature/humidity index was in the "high danger" or "emergency" categories. In addition, the handling stress of individual animals was assessed by scoring temperament during the normal 28-day weighing schedule. Correlations were tested on individual animal heat stress level and handling stress level and the level of generic *E. coli* in their feces. In addition, analyses were conducted to test for changes in prevalence of *E. coli* O157 as a result of experiencing different levels of heat stress or handling stress.

Impact: No relationship was detected between either handling stress or heat stress and generic E. coli or E. coli O157 levels or prevalence in feces. This information was critical for industry and regulatory agencies in providing healthy cattle at slaughter.

Indicator 2

During FY 2008, ARS will utilize 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.

FY 2008 Accomplishments:

1. Aflatoxin contamination is critical issue for the California almond industry valued over \$2 billion annually. ARS scientist at Albany, California, found that the navel orange worm (NOW), an insect pest, is a major contributor to promoting infection of almonds by *Aspergillus* strains that produce aflatoxin. The insect can carry the spores of this fungus to the almond kernel through feeding wounds produced by the insect, where the spores subsequently germinate and grow.

Impact: This finding will have an immediate impact on the almond industry, through implementation of controls for the insect through the use of host-plant volatiles (HPVs). The HPVs trap, confuse or distracting the insects from locating the host-plant.

2. Aflatoxins are a group of toxins produced by *Aspergillus flavus* with contamination of corn by these toxins a problem in the mid south especially in the Mississippi Delta. Reduction in mycotoxin contamination in corn will produce a safer feed/food supply that will be readily acceptable on the world market.

Impact: A patent has been issued on a non-toxigenic *A. flavus* strain designated K49 that through use as a competitor reduced aflatoxin in corn up to 93 percent under field conditions. This technology allows industry to test the use of non-toxigenic strains to develop a commercial product to control aflatoxin contamination in corn

3. Caffeic acid, an antioxidant, was found to reduce > 95 percent of aflatoxin production by *Aspergillus flavus* without affecting fungal growth. Microarray analyses of caffeic acid-treated *A. flavus* indicated expression of almost all genes in the aflatoxin biosynthetic cluster were down-regulated (decreased). These findings suggest antioxidants may trigger induction of the enzymes, alkyl hydroperoxide reductases, which protect the fungus from oxidizing agents that are produced when the fungus invades the crop. Consequently, aflatoxin synthesis is prevented through molecular regulation of toxin synthesis. ARS scientists in Albany, California and New Orleans, Mississippi, have discovered how to prevent aflatoxin production with safe, common natural chemicals. In addition, the research has shown how these compounds work in the fungus so as to turn off the aflatoxin biosynthetic machinery of the fungus. In short, the compounds trick the fungus into "thinking" that it does not need to produce aflatoxin, which are produced by the fungi to protect them from chemical attacks from plants.

Impact: This information should help in devising methods of breeding crop plants to prevent aflatoxin contamination. It also provides us with significant insights as to how to control the genes that trigger biosynthesis of aflatoxins.

4. The use of atoxigenic strains of *Aspergillus flavus* as biocontrol agents has been questioned due to the potential development of “super” toxin producers. Genetic markers with high resolution are required to measure potential genetic exchange. In order to determine genetic relationships among various atoxigenic and toxigenic strains of *A. flavus* and to determine the rate at which genes are exchanged among the various strains, high resolution molecular markers were developed by ARS scientists in Maricopa, Arizona. Sixty-eight microsatellite loci were identified from the genome sequence of *A. flavus* NRRL3357 and sequenced completely across 12 isolates from three strains from populations coexisting in Arizona and Texas. Among these microsatellite loci, 24 sites were identified as being useful for population biology studies on distribution across strains, variability within locations, and the lack of interfering variation in adjacent DNA locations.

Impact: The impact of this work is to allow design of superior and safer biocontrol strategies utilizing atoxigenic strains of *A. flavus* for use by growers and industry.

Indicator 3

During FY 2008, ARS will 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.

FY 2008 Accomplishments:

1. Detection of melamine contaminated imported food products is a critical issue for the Food and Drug Administration (FDA). ARS scientists at Beltsville, Maryland, developed a rapid, nondestructive detection/identification method for melamine and its derivatives in pet foods, based on Raman spectroscopic techniques.

Impact: A patent disclosure was approved for the method, and a Cooperative Research and Development Agreement (CRADA) was initiated resulting in the development of two prototype hand-held devices currently undergoing testing and validation in commercial settings. This work will have a direct impact on the FDA's ability to detect melamine and related contaminants in foods.

2. Monitoring of veterinary drug residues in meat and milk products is a critical issue for regulatory agencies world-wide. ARS scientists at Wyndmoor, Pennsylvania, developed and validated a new liquid chromatographic-tandem mass spectrometric (LC-MS/MS) multi-residue method for the simultaneous quantification and identification of 38 of the most widely used anthelmintic veterinary drugs (including benzimidazoles, macrocyclic lactones, and flukicides) in milk and liver. The procedure utilizes a simple modification of the ARS developed QuEChERS method, which was initially developed for pesticide residue analysis.

Impact: The new method achieved sufficiently low detection limits of quantitation for all targeted drug residues, and was successfully validated for implementation in regulatory monitoring labs in the USA, E.U and other countries.

3. Rapid methods for the detection of harmful bacterial pathogens in food are necessary to

prevent the distribution of contaminated foods, thus protecting consumers from bacterial food poisoning. In collaboration with Purdue University a semi-automated Bacteria Rapid Detection using Optical scattering Technology, or BARDOT system, was developed to identify bacteria from colonies on a plate, without the need for expensive and time consuming biochemical or microbiological tests. The simple system involves growth of the pathogens from the food in specialized liquid culture media, subsequent plating on a solid media, then shining a red laser light through a bacterial colony and collecting the image generated using a digital camera. Under test conditions the actual BARDOT analysis took 5-10 minutes to identify all bacterial colonies.

Impact: The BARDOT system (now patented) has been validated for the identification of *L. monocytogenes*, *E. coli*, *Salmonella* and *Vibrio* isolated from food and for *L. monocytogenes* isolated from clinical samples. This simple and rapid method for will have direct application to the food industry and regulatory agencies. Three BARDOT systems are currently being built for collaborative evaluation by an academic, a government, and a food testing reference lab.

4. The USDA, Agricultural Marketing Service (AMS) asked ARS to develop a method to help graders identify hairline micro-cracks in table eggs. ARS scientists in Athens, Georgia, developed a 20-egg batch-process imaging system to detect these small cracks by enhancing the cracks by pulling a small vacuum in the image chamber which has resulted in an extremely accurate method to detect the cracks. Further enhancements to the system include a user-friendly, touch-screen database method for recording the number of egg cracks and other egg features that cause downgrades, which the AMS graders are currently documenting with pen and paper.

Impact: The system will help the graders by increasing their accuracy, removing subjectivity, reducing data transfer errors, increasing their productivity, and dramatically changing the way eggs are currently graded.

5. Serotyping *Salmonella* is an expensive time consuming task, therefore, development of a rapid high-throughput molecular technique is needed by regulatory agencies. ARS scientists at Athens, Georgia, adapted our previously developed multiplex PCR *Salmonella* serotyping technique to perform on a high-throughput platform by incorporation of capillary analysis of the multiplex PCR products. The technology can identify the top 31 serotypes which represent 75 percent of all clinically isolated *Salmonella* from humans and animals.

Impact: This technology allows the determination of up to 90 isolates in a day with very little hands on time at a cost of \$1.50/sample as compared to several days and ~\$40.00 for traditional serotyping. The technology requires little training, no specific anti-sera, and works in standard DNA sequencing instruments. Further, this technique could replace traditional serotyping for most *Salmonella* isolates implicated in foodborne outbreaks. The technology is currently being validated for certification by several Federal and State public health laboratories in the US and also by the Public Health Agency of Canada.

Indicator 4

During FY 2008, ARS will 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.

FY 2008 Accomplishments:

1. Blade tenderization is a process whereby needles are used to tenderize whole muscle pieces of meat that are then cut into steaks. The potential problem is that the process of tenderization may force cells of pathogenic bacteria that reside on the outside of the whole muscle piece of meat into the inside of the meat. The question remained, however, whether cooking would be adequate to kill cells that are inside rather than on the surface of the steaks. ARS scientists at Wyndmoor, Pennsylvania, evaluated cooking blade tenderized steaks on a commercial gas grill to eliminate E. coli O157:H7. Steaks were cooked on an open-flame gas grill to internal temperatures ranging from 120° to 140°F and showed that regardless of temperature or thickness 1,000 cells of the pathogen could be readily killed.

Impact: These results validate that mechanical blade tenderization transfers E. coli O157:H7 into the interior of steaks, with the majority of the cells remaining in the top 1 cm, and that cooking on a commercial-style gas grill is effective at eliminating cells of the pathogen that may be distributed throughout a steak that was blade-tenderized. This information is critical for both regulatory agencies such as the USDA-Food Safety Inspection Service Program, industry and consumers.

2. New classes of GRAS (generally recognized as safe) antimicrobials are in strong demand for improving mitigation strategies against L. monocytogenes in various ready-to-eat food products. The FDA has recently approved two lytic bacteriophage preparations as GRAS for food safety of ready-to-eat food products against L. monocytogenes. In collaboration with scientists at Mississippi State University scientists models have been developed to determine phage efficacy against L. monocytogenes in aquaculture products.

Impact: This research validates methods for controlling Listeria in ready-to-eat foods using bacteriophage, and will further allow the FDA to develop better risk assessments.

3. The produce industry is requesting a “kill” step to ensure the microbial safety of fresh produce and gain the confidence of consumers. ARS scientists at Wyndmoor, Pennsylvania, demonstrated that a dose of 1 kGy radiation can achieve at least 99.999% (5 log) reduction of E. coli O157:H7 inoculated onto the surface of fresh produce. ARS further examined the effect of irradiation on the quality of 13 common fresh-cut vegetables (Iceberg, Romaine, red and green leaf lettuce, spinach, tomato, cilantro, parsley, green onion, carrot, broccoli, red cabbage, and celery) after irradiation at 1 kGy. The appearance, texture, and aroma of most of the 13 common fresh-cut vegetables were not negatively affected, even after 14 days storage. The vitamin C content was reduced in a few vegetables. No detectable amount of furan (a possible carcinogen) was produced from irradiation.

Impact: This information is critical to the real-world application and implementation of irradiation as a food safety intervention for fresh produce. The accomplishment was also critical in providing data to the FDA, who subsequently approved irradiation of lettuce by industry.

Indicator 5

During FY 2008, ARS will 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.

FY 2008 Accomplishments:

1. Contamination of leafy-green, fresh cut produce is a major food safety concern. ARS scientists at Beltsville, Maryland, examined how long *E. coli* O157:H7 could survive under field conditions on spinach leaves. Survival was evaluated on spinach plants and in organic soil in a growth chamber that simulated field conditions. Populations of *E. coli* O157:H7 survived for a shorter duration on spinach shoots than in soil. Non-pathogenic *E. coli* were detected intermittently on spinach up to 28 days. These populations were not affected by the addition of fertilizer close to day 14 of the studies.

Impact: The results suggest that survival of *E. coli* strains were similar on leaves and in rhizosphere soil. This work is critically important for producers and regulatory agencies for developing good agricultural practices for fresh cut produce.

2. Bacteria have become increasingly resistant to antibiotics, raising concern for health caregivers and the medical community that antibiotic resistance may be transferred from animals to humans. Definitive evidence of the occurrence or non-occurrence of animal-to-human transfer of antimicrobial-resistant microbes is lacking, however, largely due to the lack of controlled study populations. ARS scientists at College Station, Texas, in collaboration with Texas A&M University, studied a semi-closed fully integrated swine production operation and discovered that certain production groups of swine, such as boars and nursery piglets, and that certain worker populations, such as slaughter plant workers, were at higher risk of carrying multidrug-resistant *E. coli* than were other populations within the operation.

Impact: This accomplishment has important food safety implications because it suggests that certain production practices and occupational exposures may increase the risk of antibiotic resistance transfer in pathogenic microorganisms. The accomplishment has identified potential critical control points that may be targeted for interventions to reduce the transmission of antimicrobial-resistant bacteria from farm animals to humans.

3. Little is known about specific plant factors that affect the colonization of lettuce by the human pathogens *E. coli* O157:H7 and *Salmonella enterica*. Such information is necessary in order to develop adequate good agricultural practices (GAPs) and Hazard analysis critical control point (HACCP) guidelines for the produce industry. ARS scientists in Albany, California, demonstrated that enteric pathogens had higher growth rates and grew to greater population sizes on the young inner leaves of than on the older middle leaves of Romaine lettuce. This difference in colonization was partly attributable to differences in nitrogen levels available to bacterial cells on the surface of the leaves.

Impact: These observations are valuable for risk assessment analysis of produce contamination, for development of efficient sampling strategies to detect contamination of produce, and for the design of a control strategy based on modulation of nitrogen fertilization of lettuce in the field.

4. Although chickens infected with *Salmonella enteritidis* do not deposit this pathogen inside egg yolks very often, bacteria from the surrounding albumen might penetrate through the membrane that surrounds the yolk, resulting in rapid and extensive *Salmonella* growth in the nutrient-rich interior contents of the yolk prior to egg refrigeration. ARS scientists in Athens, Georgia, used a laboratory egg contamination model to assess the ability of *S. enteritidis* strains to multiply on the vitelline membrane or to penetrate this membrane and multiply inside yolks during incubation at warm temperatures (simulating the conditions under a

proposed National *S. enteritidis* Control Program that would allow unrefrigerated storage of eggs on farms for up to 36 hours). Studies determined that *S. enteritidis* were all able to penetrate from the exterior of the yolk (vitelline) membrane into the yolk contents during as little as 12 hours of incubation at 30°C. The concentration of *S. enteritidis* after incubation was significantly higher in whole yolks, than in yolk contents at both 12 hours and 36 hours.

Impact: These results demonstrate that extensive bacterial multiplication on the yolk membrane may occur in addition to (and before) penetration into the yolk contents, further supporting Federal regulatory rules that emphasize rapid refrigeration of eggs for protecting consumers from egg-borne illnesses by *Salmonella*.

- Worldwide, surface waters are being made more estrogenic because of the excretion of natural estrogens by food animals in concentrated confinement and especially by synthetic estrogens excreted by humans. Synthetic estrogens are incompletely removed by municipal sewage treatment plants and natural estrogens may be incompletely removed by agricultural waste handling systems. In this study, ARS scientists in Fargo, ND, demonstrated that trace levels of Fe-TAML (a commercially available chemical) makes hydrogen peroxide more efficient at degrading natural and synthetic reproductive hormones present in water.

Impact: The study demonstrated that Fe-TAML and hydrogen peroxide may be useful in removing natural and synthetic estrogens from agricultural and municipal waste streams. The work will have both national (EPA) and international impact, particularly in high contaminated areas of the globe, on the bioremediation of water sources.

- Along with potent neurotoxins (BoNT), the crude food poisoning mixture produced by *Clostridium botulinum* bacteria includes other non-toxic proteins. ARS scientists in Albany, CA compared the toxicity of crude versus purified BoNT preparations presented to mice in food, and showed these accessory proteins protect BoNT from destruction and inactivation in the digestive tract.

Impact: These results help scientists understand how these potent biothreat toxins work and to develop strategies for maintaining a safe and secure food supply. Understanding the stability of these biothreat toxins will help government agencies and food processors develop strategies for maintaining a safe and secure food supply.

Measure 4.1.1 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, 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, APHIS, ERS, CDC, FDA, DHS, DoD, FBI, CIA, Risk Assessment Consortium, Codex Alimentarius Commission, academia, and consumer and commodity organizations.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Determined whether blade tenderization of whole muscle pieces of meat had the potential to force cells of pathogenic bacteria that	These results validated that mechanical blade tenderization transfers <i>Escherichia coli</i> O157:H7 into the interior of steaks,	This information is critical for public health regulatory agencies such as the USDA-Food Safety Inspection Service	Determined that cooking blade tenderized steaks on a commercial gas grill to an internal temperatures ranging from 120° to 140°F

STRATEGIC GOAL 4

reside on the outside of the whole muscle piece of meat into the inside of the meat. Subsequently, determined whether cooking killed the bacterial contamination of the meat.	with the majority of the cells remaining in the top 1 cm, and that cooking on a commercial-style gas grill is effective at eliminating cells of the pathogen that may be distributed throughout a steak that was blade-tenderized.	Program, industry such as the national Cattleman's Beef Association, consumer organizations, and consumers.	eliminated 1,000 cells of Escherichia coli O157:H7, regardless of the thickness of the steak.
Developed and validated a serotyping technology that can identify the top 31 Salmonella serotypes which represent 75% of all clinically isolated Salmonella from humans and animals.	Development of a rapid, high-throughput molecular multiplex PCR technology combined with rapid capillary analysis of the multiplex PCR products.	Federal and State public health laboratories in the USA, and other international public health and regulatory agencies.	The technology allows the determination of up to 90 Salmonella isolates in a day with very little hands on time at a cost of \$1.50/sample as compared to several days and ~\$40.00 for traditional serotyping. The technology requires little training, no specific anti-sera, and works in standard DNA sequencing instruments. Further, this technique could replace traditional serotyping for most Salmonella isolates implicated in foodborne outbreaks
Development and validation of a technology to identify hairline micro-cracks in the shells of chicken eggs.	Developed a 20-egg batch-process imaging system to detect small cracks in shell eggs by enhancing the cracks through pulling a small vacuum in the image chamber. The system is further enhanced through a user-friendly, touch-screen database method for recording the number of egg cracks and other egg features that cause downgrades.	USDA, Agricultural Marketing Service, and chicken egg producers/processors	The system will help the graders by increasing their accuracy, removing subjectivity, reducing data transfer errors, increasing their productivity, and dramatically changing the way eggs are currently graded.
Developed and validated an optical detection technology for bacterial pathogens	In collaboration with Purdue University developed a semi-automated Bacteria Rapid Detection using Optical scattering Technology, (BARDOT) system to identify bacteria from colonies on a plate, without the need for expensive and time consuming biochemical or microbiological tests.	USDA-FSIS, FDA, DHS, FBI, public health, regulatory and defense agencies in other countries, and industry.	The technology took 5-10 minutes to identify all bacterial colonies on a medium plate. The patented technology has been validated for the identification of L. monocytogenes, E. coli, Salmonella and Vibrio isolated from food and for L. monocytogenes isolated from clinical samples.
Developed and validated a new technology for the simultaneous quantification and identification of 38 of the most widely used anthelmintic veterinary drugs	The procedure utilizes a modification of the ARS developed QuEChERS method initially developed for pesticide analysis, combined with liquid chromatographic-tandem	Regulatory monitoring labs in the USA, EU and other countries internationally.	Successful ability to rapidly and effectively monitor veterinary drug residues in meat and milk products. The new technology achieved sufficiently low detection limits of

mass spectrometry (LC-MS/MS) for the multi-residue determination of veterinary drugs including benzimidazoles, macrocyclic lactones, and flukicides.

quantitation for all targeted drug residues, and was successfully validated by the AOAC for worldwide implementation.

Measure 4.1.1 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

utilize 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.

utilize 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.

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.

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.

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.

During FY 2010, ARS will

utilize 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.

utilize 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.

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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.

During FY 2011, ARS will

utilize 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.

utilize 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.

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 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.

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.

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.

OBJECTIVE 4.2: REDUCE THE NUMBER, SEVERITY AND DISTRIBUTION OF AGRICULTURAL PEST AND DISEASE OUTBREAKS

Safeguarding workers, property, domestic animals, and crop plants from pests and diseases is essential to American agriculture. Left without protection, agricultural production would decrease dramatically, threatening the Nation's prosperity and security. Because the United States is the world's largest exporter of agricultural goods, threats to U.S. agriculture are threats to our trading partners as well. Many pests and diseases are native to the United States; others have succeeded in becoming invasive pests, and yet others are likely to be introduced and established. Resources for preventing these problems are always going to be scarce in relation to the challenges, so the best knowledge available is necessary to focus the effort. An increasingly global agricultural economy and the threat of agroterrorism make the recognition and identification of potential new problems important and their prevention all the more challenging.

In the course of agricultural production, processing, and marketing, a wide array of pathogens and pests can threaten efficiency. The extent of damage depends on several factors. Influences such as globalization, international commerce, and the industrialization of agriculture can necessitate the increased movement of animals during production, lead to an increased presence of arthropod vectors, and increase the resistance of disease-carrying pathogens, ultimately increasing the severity of diseases and pests for crops, livestock, or even humans.

Researchers' efforts to improve the efficacy of early detection and surveillance systems; increase the availability of vaccines, biotherapeutics, insecticides, and other protection systems; and develop effective quarantine measures can greatly decrease the severity of diseases and pests.

ARS plays a vital role in defending the Nation's agriculture from pathogens and pests, providing the knowledge necessary for agriculture to adapt to changing conditions. To shape its research efforts, the Agency regularly examines Homeland Security issues that might affect the quality of the Nation's food and fiber. ARS conducts research to find the best methods of protecting and treating agricultural commodities in storage facilities; reduce contamination from improper storage practices; and develop integrated systems for risk assessment, surveillance, treatment, and monitoring of pests and diseases. ARS maintains partnerships with Federal and State agencies and industry and professional organizations, whereby knowledge and discoveries are refined and applied to develop products and integrated systems to optimize protective efforts against pests and pathogens.

Key Outcome: The knowledge the Nation needs for a secure agricultural production system and healthy food supply.

Performance Measures

Measure 4.2.1 Provide scientific information to protect animals, humans, and property from the negative effects of pests, infectious diseases, and other disease-causing entities.

Baseline 2005

Two research studies completed that had significant impact on the scientific community and will lead to new technologies for protection of humans, property, and livestock from harm due to pests or diseases.

Target 2011

Cumulatively, complete 10 research studies that have significant impact on the scientific community, leading to development of technologies for the integration of prevention and treatment strategies to manage top priority endemic and exotic threats to livestock, humans, and property.

Indicator 1

During FY 2008, 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.

FY 2008 Accomplishments:

1. Consumers continue to have increasing concerns over the use of antibiotics to control diseases in farm animals. ARS scientists at the Beltsville Animal Parasitic Diseases Laboratory used a high-throughput sequencing strategy to discover a new avian protein in activated intestinal lymphocytes that may have the ability to control coccidiosis. The DNA sequence of the gene coding for this protein is homologous to human NK-lysin. Although the chicken NK-lysin showed relatively low amino acid sequence similarity to mammalian NK-lysin (< 20%), it possessed the characteristically conserved amino acid residues that are the hallmarks of the saposin protein family antimicrobial activity. Although preliminary studies demonstrated an anti-tumor effect, chicken NK-lysin lacked antibacterial activity. Chicken recombinant NK-lysin was cytotoxic for *Eimeria acervulina* and *Eimeria maxima* parasites indicating its important role in innate immune response to avian coccidiosis. Future studies using synthetic peptides derived from NK-lysin may be useful for pharmaceutical and agricultural uses in the food animal industry.

Impact: This is the first isolation of an anti-infective protein from intestinal lymphocytes and may lead to the development of innovative intervention strategies that reduce the use of antibiotics in poultry.

2. Texas cattle fever was eradicated from the United States through controlling the tick vector, *Rhipicephalus microplus*. Recent re-emergence of acaricide resistant vector ticks has increased the potential for Texas cattle fever to re-emerge in increasing severity in the U.S. The causative agent, *Babesia bovis* is transmitted between cows by the *Rhipicephalus microplus* tick. New methods to control vector ticks and/or the disease are needed to control this potentially serious disease of cattle. ARS scientists from the Animal Research Unit in Pullman, WA in collaboration with Washington State University have stably transfected (inserted) a foreign gene into the red blood cell stage of *B. bovis*. This will enable scientists to insert other genes such as those coding for tick antigens which could induce immunity against the ticks.

Impact: This new research will potentially allow scientists to identify virulence genes and develop new and novel vaccine candidates through the insertion or alteration of genes in the *B. bovis* organism. This information is critical for the development of anti-babesial vaccines including those which block transmission between animals.

3. Vesicular stomatitis virus appears in outbreaks in the US at irregular intervals, disrupting movement of animals and causing the need to rule out the symptomatically similar foot-and-mouth disease. ARS entomologists at the Arthropod-Born Animal Diseases Laboratory, Laramie, demonstrated that a biting midge that transmits vesicular stomatitis virus to livestock did not feed as successfully when it was infected with the virus. The delay in feeding increases the likelihood that the virus will reach infective levels in more individual midges. Blood feeding is a dangerous time for the individual insect so that a delay increases the likelihood that the midge will be infective by the time it takes a second or subsequent blood meal. Risk estimates of vesicular stomatitis transmission would normally be based on longevity of the midge population taken as a whole.

Impact: This discovery shows that longevity should be estimated based on the infected population, potentially causing a great change in estimates of risk.

4. Formosan subterranean termites were introduced into the US in the 1940s and have since become a severe pest of structures in the Southeast. Scientists at the Natural Products

Utilization Research Unit, Oxford, and at the Formosan Subterranean Termite Research Unit, New Orleans, discovered a naturally occurring compound that kills termites, leading to a patent and exploration of analogous compounds. In addition, a fungal extract revealed a single chemical that acted as a powerful attractant and feeding stimulant to the termites.

Impact: This work may lead to completely new termiticides with low mammalian toxicity. The attractant could be combined with toxicants to make more effective termite control devices.

5. The cattle fever tick is reinvading the US following over 60 years of eradication, raising the probability of reintroduction of bovine babesiosis and making cattle production uneconomical in the southern US. ARS scientists at the Knippling-Bushland US Livestock Insects Research Laboratory, Kerrville, and the Animal Disease Research Unit, Pullman, have used a variety of cutting-edge techniques to find targets in the cattle fever tick that could be attacked by vaccines. These targets are associated with the salivary gland proteins, anticoagulants secreted by ticks during feeding, and tick ovarian proteins. Extensive work toward describing the complicated genome of this tick leverages the biochemical work by identifying the genes that could be used to produce antigens for the vaccine products.

Impact: An effective anti-tick vaccine could decrease the transmission potential of cattle fever ticks within the US and synergize efforts to eliminate the ticks by dipping cattle in pesticide solutions. A vaccine applied to wild deer would eliminate deer as a feral source of ticks that later infest cattle.

Indicator 2:

During 2008, ARS will 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.

FY 2008 Accomplishments:

1. Although viruses of each of the 16 influenza A HA subtypes are potential human pathogens, only viruses of the H1, H2, and H3 subtype are known to have successfully established infections in humans. H2 influenza viruses have been absent from human circulation since 1968, and as such pose a substantial human pandemic risk. ARS National Animal Disease Center (NADC) scientists reported this year the isolation and characterization of an avian/swine reassortant H2N3 influenza A virus isolated from diseased swine from two farms in the United States. This virus contained an amino acid on the H2 protein that has been associated with increased binding affinity to the mammalian receptor for influenza viruses, and the H2N3 viral isolate was shown to cause disease in experimentally infected swine. In addition, the swine H2N3 virus was infectious and highly transmissible in swine and ferrets.

Impact: The identification of genetic changes in this H2N3 virus and its adaptation to a mammalian host raises concerns and highlights the need to monitor closely its potential spread. This virus may be a potential vaccine candidate should the H2N3 swine influenza virus re-emerge and begin to circulate among the U.S swine or human population.

2. Avian influenza viruses of many different antigenic subtypes (H1-H16) are found commonly in wild birds, but only the H5 and H7 subtypes are known to have the potential for being highly pathogenic in poultry. The H5N1 subtype is of particular importance because of the widespread outbreaks of highly pathogenic avian influenza in Europe, Asia, and Africa, and

extensive surveillance of wild birds was conducted in the Americas to evaluate the chance of these highly pathogenic viruses entering the United States through wild birds. Several H5N1 low pathogenic avian influenza (LPAI) viruses were isolated in wild birds by ARS scientists at SEPRL, Athens, Georgia, in collaboration with Animal and Plant Health Inspection Service (APHIS) and United States Geological Survey (USGS), and these viruses were sequenced and shown to be of North American lineage that are separate from the H5N1 highly pathogenic avian influenza (HPAI) viruses found in Europe, Asia, and Africa. This study also included experimental animal studies in collaboration with The Ohio State University that showed that these viruses did not replicate well in poultry and pose only a small threat of introduction to our poultry populations.

Impact: The biologic and sequence characterization of these viruses continue to provide evidence that H5N1 HPAI viruses have not traveled to the Americas in wild birds, and clearly documents that H5N1 LPAI viruses are normally found at a low prevalence level in the Americas.

3. A H5N1 highly pathogenic avian influenza (HPAI) virus has recently emerged in waterfowl in that is deadly to poultry and humans. Genetic reassortment of H5N1 HPAI viruses with currently circulating human influenza A virus strains could lead to efficient human-to-human transmission and result in an influenza pandemic. Domestic pigs, which are susceptible to infection with both human and avian influenza A viruses, are one of the natural hosts where such reassortment events could occur. ARS scientists at the National Animal Disease Center (NADC) in collaboration with ARS scientists at the Southeast Poultry Research Laboratory (SEPRL) conducted a study in two to three-week-old domestic piglets that were intranasally inoculated with four H5N1 HPAI viruses. Swine H3N2 and H1N1 viruses were also studied as a positive control for swine influenza virus infection. Replication of all four H5N1 viruses in pigs was restricted to the respiratory tract, mainly to the lungs. Titers of H5N1 viruses in the lungs were lower than those of swine viruses. H5N1 viruses were isolated from nasal turbinate of infected pigs. Histological examination revealed mild to moderate bronchiolitis and multifocal alveolitis in the lungs of pigs infected with H5N1 viruses, while infection with swine influenza viruses resulted in severe tracheobronchitis and bronchointerstitial pneumonia. Pigs had low susceptibility to infection with H5N1 HPAI viruses. Inoculation of pigs with H5N1 viruses resulted in asymptomatic to mild symptomatic infection restricted to the respiratory tract and tonsils in contrast to mouse and ferrets animal models, where some of the viruses studied were highly pathogenic and replicated systemically.

Impact: These results suggest swine have a low susceptibility to these H5N1 viruses and may not play a role in their transmission.

4. Bovine Viral Diarrhea Virus (BVDV) is a costly disease that affects cattle and other ruminants. The virus has many nasty effects, including fever, diarrhea, respiratory and reproductive disease, abortion, birth defects, and death. BVDV is thought by many to be the most important endemic viral disease of cattle, with economic losses estimated at about \$50-100 per cow. Design of effective programs geared toward the eradication of BVDV in domestic cattle will require an understanding of BVDV infections in wild ungulates, which are frequently in contact with domestic cattle. ARS scientists at NADC, Ames, Iowa, investigated the potential for does to become persistently infected and serve as a source of infection for our domestic cattle herds. White-tailed does were infected with BVDV, isolated from deer in the field, during the first trimester of pregnancy. Infection resulted in death or reproductive failure (abortion, reabsorption, stillbirth) in 11 out of 13 naïve does. Histological and immunohistochemical examination of persistently infected fawns revealed that BVDV antigen was distributed widely throughout many tissues and cell types, most notably epithelium and vascular endothelium, consistent with that reported in cattle. In contrast to cattle, lymphocytes exhibited only very rare positive staining.

Impact: These findings indicate that BVDV infection results in clinically severe reproductive disease in deer and that there may be differences in the way the virus behaves in deer compared to cattle. These findings also suggest that the impact BVDV reproductive disease in deer may be under appreciated and that because the virus may be spread differently from deer than cattle, different control strategies may be needed.

Measure 4.2.1 Summary of the Major Scientific Discoveries, Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS reported five new scientific discoveries, transferred and used by the scientific community, the private sector, and government agencies to develop control measures to manage priority endemic and foreign animal disease threats.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
ARS scientists developed and bench validated new Real Time RT-PCR protocols for the rapid detection of the subtypes H6, H9 and H11 of avian influenza viruses.	This information was published in a relevant peer-reviewed publication: Das, A., Suarez, D.L. 2007. Development and bench validation of real-time reverse transcription polymerase chain reaction protocols for rapid detection of the subtypes H6, H9, and H11 of avian influenza viruses in experimental samples. Journal of Veterinary Diagnostic Investigation. 19:625-634.	Scientists and diagnosticians in APHIS, CDC, DoD and public health and defense agencies in other countries.	Avian influenza virus has 16 distinct antigenic subtypes, but certain subtypes are responsible for most diseases outbreaks in poultry. The H6, H9, and H11 subtypes are commonly found in other countries and rapid diagnostic tools are needed to rapidly diagnose these subtypes if they infect poultry in the United States. A real-time reverse transcriptase polymerase chain reaction (RT-PCR) test for the rapid identification of H6, H9, and H11 subtypes of avian influenza will provide additional tools to diagnose avian influenza outbreaks.
Isolation and characterization of an avian/swine reassortant H2N3 influenza A virus isolated from diseased swine from two farms in the United States.	This information was published in a relevant peer-reviewed publication: Ma, W., Vincent, A.L., Gramer, M.R., Brockwell, C.B., Lager, K.M., Janke, B.H., Gauger, P.C., Patnayak, D.P., Webby, R.J., Richt, J.A. 2007. Identification of H2N3 influenza A viruses from swine in the United States. Proceedings of the National Academy of Science (PNAS). 104(52):20949-20954.	APHIS, CDC, NIH, veterinary schools, swine farmers, and international public health agencies.	ARS scientists demonstrated that the avian/swine reassortant H2N3 influenza A virus contained an amino acid on the H2 protein that has been associated with increased binding affinity to the mammalian receptor for influenza viruses, and the H2N3 viral isolate was shown to cause disease in experimentally infected swine. In addition, the swine H2N3 virus was infectious and highly transmissible in swine and ferrets. These findings suggest that this H2N3 virus has undergone some adaptation to the

mammalian host and that its potential spread should be very closely monitored. In addition, this virus is now available for potential vaccine development should the H2N3 swine influenza virus re-emerge and begin to circulate among the U.S swine population.

Measure 4.2.1 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

investigate the pathogenesis of important pathogens of livestock and poultry to understand mechanisms of disease.

investigate the genomics of important farm animals, pathogens, and arthropods to understand host-pathogen interactions.

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

During FY 2010, ARS will

further investigate the pathogenesis of important pathogens of livestock and poultry to understand mechanisms of disease.

further investigate the genomics of important farm animals, pathogens, and arthropods to understand host-pathogen interactions.

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

elucidate arthropod behaviors and physiological mechanisms that either cause damage or which could be used to prevent damage

During FY 2011, ARS will

further investigate the pathogenesis of important pathogens of livestock and poultry to understand mechanisms of disease.

further investigate the genomics of important farm animals, pathogens, and arthropods to understand host-pathogen interactions.

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

discover scientific information that informs the selection of technologies for integrated pest management of arthropods that harm humans, animals, and structures.

Measure 4.2.2 Develop and transfer tools to the agricultural community, commercial partners, and government agencies to control or eradicate domestic and exotic diseases and pests that affect animal and human health.

Baseline 2005

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

Target 2011

Cumulatively, transfer five technologies to the commercial and government sectors.

Indicator 1:

During FY 2008, ARS will form new partnerships and continue old partnerships with industry, universities, and other government agencies in order too promote production and marketing of new methods for detection and identification of animal pathogens, arthropods that transmit pathogens, and arthropods that destroy property; including genetic markers, new methods of detecting gene sequences or antibodies or proteins, and comprehensive guides to morphological identification.

FY 2008 Accomplishments:

1. ARS scientists at the SEPRL, Athens, Georgia, developed and bench validated a new Real Time RT-PCR protocols for the rapid detection of the subtypes H6, H9 and H11 of avian influenza viruses. Avian influenza virus has 16 distinct antigenic subtypes, but certain subtypes are responsible for most diseases outbreaks in poultry. A real-time reverse transcriptase polymerase chain reaction (RT-PCR) test for the rapid identification of H6, H9, and H11 subtypes of avian influenza were developed and bench validated.

Impact: The rapid detection and identification of avian influenza viruses, particularly the H6 and H9 subtypes, provide additional tools to diagnose avian influenza outbreaks. The H6 and H9 subtypes are commonly found in other countries and rapid diagnostic tools are needed to rapidly diagnose if these subtypes infect poultry in the United States.

2. Paratuberculosis (Johne's disease) is a chronic wasting enteric disease of ruminants caused by infection with a bacterial pathogen, Mycobacterium avium subsp. paratuberculosis. Johne's disease results in significant economic losses to the cattle industry due to animal culling, reduced milk production, poor reproductive performance and reduced carcass value. Diagnosis of cattle infected with Johne's is difficult due to the long incubation time between

infection and the onset of clinical disease. This past year, ARS scientists at the National Animal Disease Center (NADC), in Ames, IA identified 6 novel antigens that may be candidates for an improved diagnostic test for Johne's disease. The scientists identified the antigens through the use of a newly developed 96-spot protein assay. Studies using the protein assay have determined that some proteins can be detected as early as 70 days of infection of cattle with the *M. paratuberculosis*.

Impact: Early diagnosis of infected cattle will allow improved control strategies on a herd basis through isolation and culling of infected animals.

3. New active ingredients for mosquito control are seldom developed. As existing active ingredients are eliminated by regulatory concerns and development of resistance, a gap is developing in the ability to control mosquitoes. ARS scientists at the Mosquito and Fly Research Unit, Gainesville, worked together with the University of Florida to model compounds repellent to mosquitoes. Over 2,000 compounds that had been tested at the research unit formed the database for molecular modeling on a computer. Subsequent synthesis and bioassay of new molecules resulted in seven compounds that are longer-lasting than DEET, the most commonly used repellent active ingredient. Systematic examination of piperidines compounds with modification of some molecular side groups resulted in development of one new molecule that is highly toxic to mosquitoes. Extending efforts with molecular pesticides, scientists showed that the double stranded RNA that inhibits regulation of programmed cell death selectively kills mosquitoes and not other kinds of flies. A new system for high-throughput screening of trial compounds using first instar mosquito larva was developed and used to screen over 2,000 compounds. Pesticide development requires years of effort and large investment by industry. By performing the discovery phase of toxicant development, ARS is stimulating industry to develop compounds that are needed to fill in the gaps for mosquito control.

Impact: New toxicants developed by ARS have been designed to address specific needs of the mosquito control industry, including repellency, specificity, and environmental safety.

4. The Screwworm Eradication Program operated by APHIS successfully excludes this pest from all of North America by maintaining a barrier of sterile male flies in eastern Panama and the program is always looking for efficiencies that will reduce costs of this program. ARS entomologists at the Screwworm Research Unit, Pacora, performed a field study to show that the new production strain of the screwworm fly, Jamaica-06, is just as effective as the strain that has been in use for over five years. The Screwworm Research Unit also performed rapid-response research to determine how best to reduce ammonia production in the larval medium, a problem that had become a major impediment to operating the new Panama production plant. ARS scientists at the Insect Genetics and Biochemistry Research Unit, Fargo, applied cryopreservation techniques they had developed during two decades to practical preservation of screwworm flies. These scientists trained technicians at the screwworm production plants in Mexico and Panama to perform this procedure reliably. Jamaica-06 has replaced the old strain, which had become overly adapted to production conditions and less competitive in the field.

Impact: The selection of a medium that produces a minimum of ammonia has enabled APHIS to plan on scaling up the Panama plant to full production during the first half of 2009. Cryopreservation will eliminate the need to continuously maintain specialty strains of screwworm flies, reducing costs. Under development is a mass cryopreservation technique that will also eliminate the need for backup colonies that cost over \$100,000 per year to maintain.

5. The Formosan subterranean termite became established in the US in the 1940s. Since then it has proven to be the most damaging termite species where it occurs, threatening the existence of historical buildings in the French Quarter of New Orleans. During 11 years of effort, the ARS has managed trial programs to reduce the population of Formosan subterranean termites in the French Quarter of New Orleans to levels that no longer threaten historical buildings. Working with many academic partners and local institutions (the New Orleans Mosquito and Termite Control Board and the Audubon Institute), ARS has developed methods for risk assessment, surveillance, and control that have finally succeeded in achieving overall population reductions of the termite in the French Quarter. The program monitors flying termites that periodically swarm in a natural process to establish new colonies.

Impact: These results show a reduction of 44% to 75% of termites in the French Quarter. Individual colonies have been targeted with baits that use a minimum of a very safe pesticide. By targeting efforts to places where colonies are detected by inspection and acoustics, the program has systematically eliminated or controlled colonies from especially problematic buildings and from major sources of termites like the Mississippi River levee. Historical buildings of the French Quarter of New Orleans has been saved from destruction and the strategies developed in the program will be useful throughout the southeastern US where the Formosan subterranean termite occurs.

Indicator 2:

During 2008, ARS will 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 destroy property.

FY 2008 Accomplishments:

1. The cattle fever tick is reinvading the US following over 60 years of eradication, raising the possibility of reintroduction of bovine babesiosis and making cattle production uneconomical in the southern US. ARS scientists at the Knippling-Bushland US Livestock Insects Research Laboratory, Kerrville, have examined the expressed genome of the nerve concentration known as the synganglion in the cattle fever tick. They found that there are multiple copies of the gene encoding an enzyme essential for nervous transmission and that these copies produce variations of this enzyme. This discovery shows that the tick has the potential of rapidly developing resistance to the principle pesticide used to control it. Fortunately, field studies by ARS have continued to show that ticks found in infestations in the US are susceptible to the pesticide coumaphos. They have also developed more rapid biochemical tests to detect resistance to this class of pesticides. Treatment failures may be the result of treating cattle during rainy weather, which greatly decreases success. Other work by ARS demonstrated that an alternative ivermectin treatment was less effective than indicated on the label. They also improved the design of the 4-poster for treatment of wild deer (a device that applies a pesticide to deer that are attracted to corn delivered as a bait), preventing feeding on the corn bait by non-target animals. Tests of a combination of pyrethroid and amitraz indicated that the combination might be effective against ticks resistant to either pesticide by itself. Because the cattle fever tick eradication program is completely dependent on the pesticide coumaphos, an anti-acetylcholinesterase toxicant, priority research should be applied to either finding alternative chemicals or synergists that will extend the effectiveness of the pesticide. One of the potential alternative treatments, ivermectin, is not performing as well as might be hoped.

Impact: Although the 4-poster continues to be improved, it is only useful in certain special situations for treatment of deer that support populations of the cattle fever tick. Pyrethroid-amitraz combinations might offer a solution, especially if they were used to take advantage of the physiological selection pressure against amitraz-resistant ticks. The most important impact of these research results is that the pace of research on control of the cattle fever tick needs to be increased significantly in order to avoid disastrous economic consequences for the cattle industry in the southern US.

2. The Screwworm Eradication Program operated by APHIS successfully excludes this pest from all of North America by maintaining a barrier of sterile male flies in eastern Panama and the program is always looking for efficiencies that will reduce costs of this program. ARS entomologists at the Screwworm Research Unit, Pacora, performed a field study to show that the new production strain of the screwworm fly, Jamaica-06, is just as effective as the strain that has been in use for over five years. The Screwworm Research Unit also performed rapid-response research to determine how best to reduce ammonia production in the larval medium, a problem that had become a major impediment to operating the new Panama production plant. ARS scientists at the Insect Genetics and Biochemistry Research Unit, Fargo, applied cryopreservation techniques they had developed during two decades to practical preservation of screwworm flies. These scientists trained technicians at the screwworm production plants in Mexico and Panama to perform this procedure reliably. Jamaica-06 has replaced the old strain, which had become overly adapted to production conditions and less competitive in the field.

Impact: The selection of a medium that produces a minimum of ammonia has enabled APHIS to plan on scaling up the Panama plant to full production during the first half of 2009. Cryopreservation will eliminate the need to continuously maintain specialty strains of screwworm flies, reducing costs. Under development is a mass cryopreservation technique that will also eliminate the need for backup colonies that cost over \$100,000 per year to maintain.

3. The Formosan subterranean termite became established in the US in the 1940s. Since then it has proven to be the most damaging termite species where it occurs, threatening the existence of historical buildings in the French Quarter of New Orleans. During 11 years of effort, the ARS has managed trial programs to reduce the population of Formosan subterranean termites in the French Quarter of New Orleans to levels that no longer threaten historical buildings. Working with many academic partners and local institutions (the New Orleans Mosquito and Termite Control Board and the Audubon Institute), ARS has developed methods for risk assessment, surveillance, and control that have finally succeeded in achieving overall population reductions of the termite in the French Quarter. The program monitors flying termites that periodically swarm in a natural process to establish new colonies. These results show a reduction of 44% to 75% of termites in the French Quarter. Individual colonies have been targeted with baits that use a minimum of a very safe pesticide.

Impact: By targeting efforts to places where colonies are detected by inspection and acoustics, the program has systematically eliminated or controlled colonies from especially problematic buildings and from major sources of termites like the Mississippi River levee. Historical buildings of the French Quarter of New Orleans has been saved from destruction and the strategies developed in the program will be useful throughout the southeastern US where the Formosan subterranean termite occurs.

4. Filth flies, particularly the house fly, are attracted to the water sources and fecal odors of American military encampments. Moderate and large fly populations increase the risk of diarrheal disease, the primary cause of lost duty time in deployed American military personnel, by amplifying pathogenic bacteria in their guts and by mechanically transmitting

the bacteria from feces. ARS scientists at the Mosquito and Fly Research Unit, Gainesville, systematically compared common types of commercial fly traps, finding a wide variation in efficiency. They showed that the trap currently used by the military is not very efficient. ARS worked with the Armed Forces Pest Management Board to add a more efficient fly trap to the logistics system, which makes the trap available to deployed military personnel. ARS scientists also developed a field expedient fly trap made from a water bottle, demonstrating that simply painting the top of the trap black increased catches by six fold.

Impact: A new synthetic attractant blend developed by ARS could replace foul-smelling and messy baits currently in use in fly traps. Better, practical tools for fly control could reduce the rate of disease non-battle from rates as high as 20% per week to 4% per week. The availability of healthy military personnel acts as a force multiplier, reducing the number of personnel who must be deployed in order to accomplish the mission.

5. New active ingredients for mosquito control are seldom developed. As existing active ingredients are eliminated by regulatory concerns and development of resistance, a gap is developing in the ability to control mosquitoes. ARS scientists at the Mosquito and Fly Research Unit, Gainesville, worked together with the University of Florida to model compounds repellent to mosquitoes. Over 2,000 compounds that had been tested at the research unit formed the database for molecular modeling on a computer. Subsequent synthesis and bioassay of new molecules resulted in seven compounds that are longer-lasting than DEET, the most commonly used repellent active ingredient. Systematic examination of piperidines compounds with modification of some molecular side groups resulted in development of one new molecule that is highly toxic to mosquitoes. Extending efforts with molecular pesticides, scientists showed that the double stranded RNA that inhibits regulation of programmed cell death selectively kills mosquitoes and not other kinds of flies. A new system for high-throughput screening of trial compounds using first instar mosquito larva was developed and used to screen over 2,000 compounds. Pesticide development requires years of effort and large investment by industry.

Impact: By performing the discovery phase of toxicant development, ARS is stimulating industry to develop compounds that are needed to fill in the gaps for mosquito control. New toxicants developed by ARS have been designed to address specific needs of the mosquito control industry, including repellency, specificity, and environmental safety.

Indicator 3:

During 2008, ARS will form new partnerships and continue old partnerships with industry, universities, and other government agencies in order to promote production and marketing of new methods of management of arthropods that damage property or that transmit pathogens to humans and animals.

FY 2008 Accomplishments:

1. Brucellosis is a bacterial disease that can infect domestic cattle and humans. Currently, one of the most common sources of Brucellosis in cattle in the Western States is from contact with infected Bison. Bison appear to be more susceptible to Brucella infection and clinical effects of disease. Tools are needed to resolve the high prevalence of Brucellosis in bison in Yellowstone National Park; thus preventing spread of the organism to cattle in the area. ARS scientists at the National Animal Disease Center (NADC), Ames, IA have evaluated the efficacy of a new recombinant brucellosis vaccine in protecting against infection and disease in bison.

Impact: The new vaccine was safe for use in bison following experimental challenge, although not as protective against disease and bacterial shedding as observed in vaccinated cattle. This research suggests that the current vaccines may help reduce brucellosis in bison, but vaccines need to be developed to further reduce disease and organism shedding in bison.

2. Vaccination is an emergency tool that can be used to confront outbreaks of H5N1 high pathogenicity avian influenza (HPAI), but the number of vaccine doses in the U.S National Veterinary Stockpile is limited. To determine if the available vaccine doses could be stretched by using reduced vaccine dose, but maintain adequate efficacy, a vaccination-challenge study was conducted in chickens. At full, half, one-fourth and 1/10 of the avian influenza (AI) vaccine doses, all AI vaccinated chickens were protected from disease and death, but using less vaccine than the full dose had some negative effects including reduced serological titers, more chickens excreting challenge virus, and higher quantities of challenge virus growth and excretion from intestines and respiratory system.

Impact: These studies showed the importance of using a full vaccine dose, which is especially important because protection in commercial chickens in the field is typically less than seen in experimental studies that use specific pathogen free chickens in the laboratory.

3. The biting and stinging of imported fire ants are a threat to livestock and humans where these invasive pests are abundant in the southeastern US. ARS entomologists at the Biological Control of Pest Research Unit, Stoneville, have found that the total volume of fire ant mounds is the same whether or not colonies are of the multiple queen or single queen type. The mounds can be detected by measuring five distinct wavebands in the visible, near-infrared, and mid-infrared.

Impact: Detection and quantification of fire ant mounds from aerial photography will provide an important tool for evaluation of area-wide control efforts, including the successful establishment of biological control agents discovered by ARS. On a smaller scale, detection of mounds within a field or pasture could help target the use of pesticide baits.

4. Since its introduction from South America in the early 1900s, the imported red fire ant has spread throughout the southeastern US, Texas, and parts of California. The stinging pest now threatens human health, livestock, and wildlife in states further north because of changes in climate, as well as in Hawaii because of frequent shipments from California. ARS scientists at the Imported Fire Ant and Household Insects Research Unit, Gainesville, and the South American Biological Control Laboratory, Buenos Aires, Argentina, discovered and developed small flies that attack fire ants. These flies lay an egg on an individual ant and the fly larva develops inside eventually killing the ant. These flies have made an impact on fire ant populations throughout the southeastern US. During the last year a fourth species was released and another species is under evaluation to be certain that it will not affect native species. Another important natural enemy that was discovered and developed by these laboratories is a protozoan pathogen of fire ants (*Thelohania solenopsae*). ARS scientists discovered that the parasitic flies become infected with this ant pathogen, helping to distribute the pathogen to other ant colonies. During the last two years, ARS scientists discovered two entirely new viruses of fire ants and have now determined the details of the natural infection process and described the protein coat of one of them. Another approach to biological control is to use substances within the insect to disrupt vital physiological processes. ARS discovered the first neuropeptide in fire ants, a signaling compound involved in pheromone production. One of the reasons that a single species of parasitic fly is not adequate to control the fire ant problem is that each strain of ant is attacked preferentially by a different species,

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or even strain within a species, of parasitic fly. Comparisons of the genetics of American populations of fire ants to those in South America have shown that 9-20 introductions occurred historically, with the state of Formosa, Argentina, as the likely geographical source.

Impact: The work described improves current successful efforts to reduce populations of imported fire ants throughout the US by biological control, the only way that could be environmentally and economically feasible. As more strains and species of parasitic flies are established in the US, the imported fire ants will have increasingly more difficulty outcompeting native ant species, eventually reaching an equilibrium in which the imported fire ants are much less abundant. The precise understanding of fire ant genetics enables the targeting of the right strain of parasitic fly or pathogen to the right strain of imported fire ant. New biological control agents like neuropeptides and viruses offer the promise of further integration of methods to bring imported fire ants into balance with American ecosystems

Measure 4.2.2 Summary of Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS reported five new technologies developed, transferred, and used by the private sector and government agencies to protect animals, people, and property.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
ARS scientists established a new protocol that does not need sequence-specific primers for full-length nucleotide sequencing of up to 20 RNA viruses simultaneously.	This technology was transferred to the National Veterinary Services Laboratory, Ames, Iowa.	National Veterinary Services Laboratory, USDA-APHIS.	This technology will dramatically decrease the time needed for full-length genome nucleotide sequencing of Porcine Reproductive and Respiratory Syndrome (PRRS) RNA viruses, the only method that can accurately delineate genetic differences between viral isolates. This new protocol will be used to unravel the genomes of recent novel highly pathogenic PRRS virus isolates from Vietnam, North Carolina, and Minnesota.
Avian influenza virus H7 Real-time RT-PCR (RRT-PCR) subtyping test.	A new primer test was developed and bench validated and transferred to the National Veterinary Services Laboratories (NVSL), USDA-APHIS, for further validation. The new test was shown to detect all North and South American H7 viruses with increased sensitivity over the original H7 test and was adopted as part of the official National Animal Health Laboratory Network (NAHLN) protocol	APHIS and NAHLN State Laboratories.	The avian influenza H7 Real-time RT-PCR (RRT-PCR) subtyping test was modified to improve specificity. Although the original test was designed to detect all North American strains, tests with recent H7 wild bird viruses was shown to be inadequate and miss a significant majority of positive test samples.
Improvements in tools for integrated pest	Through websites, patents, research agreements and	Public, pesticide companies, entomological	Significant reduction in target pest species and

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management of arthropods that damage humans, livestock and structures.	licensed technology	equipment companies, and government agencies.	reduction in use of pesticides.
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Measure 4.2.2 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

continue to 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.

continue to 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.

continue to 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.

form new partnerships and continue old partnerships with industry, universities, and other government agencies in order to promote production and marketing of new methods of management of arthropods that damage property or that transmit pathogens to humans and animals.

discover a biotherapeutic to modulate host response to one priority disease resulting in improved productivity of livestock animals.

During FY 2010, ARS will

continue to 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.

continue to 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.

continue to 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.

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During FY 2011, ARS will

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

form new partnerships and continue old partnerships with industry, universities, and other government agencies in order to promote production and marketing of new methods of management of arthropods that damage property or that transmit pathogens to humans and animals.

develop technologies and systems that achieve more effective integrated pest management of arthropods that harm humans, animals, and structures.

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.

Baseline 2006

Developed eight new, environmentally sound management practices that include crop resistance/tolerance through classical breeding and biotechnology, rapid and reliable diagnostics, pesticide development and use, and cultural and biological control. Biorationals have been studied and improvements explored that will provide additional protection for agriculturally important plants from pests and pathogens.

Target 2011

Specific information and technology using methods cited above will be made available to producers and the research community to exclude, control, and/or better manage disease and pest outbreaks as they occur. Strategies and approaches will be made available to producers to identify and control and/or effectively manage over 10 new and emerging crop diseases and pests.

Indicator 1:

During 2008, ARS will develop methods to reduce emissions of harmful gases from crop production systems and post-harvest/quarantine treatments.

FY 2008 Accomplishments:

1. Emission reduction is required from soil fumigation to improve air quality and adequate fumigant concentrations are needed for pest control. ARS scientists demonstrated that water seals applied to soil columns following fumigant injection significantly reduced emissions for different textured soils (e.g., loamy sand, sandy loam and clay loam) without reducing fumigant concentrations in the soil profile. The researchers also demonstrated that increasing soil water content prior to fumigant injection significantly reduced emission peaks, which would minimize acute human exposure risks to workers and bystanders.

Impact: Compared to plastic tarps, irrigation is a low-cost technique for reducing fumigant emissions, and it is especially appealing for commodities with low-profit margins in meeting environmental regulations on emission reductions.

2. There have been uncertainties on whether low permeable tarps such as virtually impermeable film (VIF) can reduce fumigant emissions in large field applications. ARS scientists demonstrated that VIF can significantly reduce fumigant emissions when fumigant was drip applied to raised-beds in large strawberry fields. In additional studies, ARS scientists showed that VIF consistently decreased emissions to the atmosphere of all of the fumigants that were tested [methyl bromide, 1,3-dichloropropene, chloropicrin, methyl isothiocyanate (from metam sodium)] in raised bed plasticulture conditions. One study showed that use of VIF film could reduce the amount of fumigant required to achieve equal effectiveness compared with use of standard polyethylene films.

Impact: VIF provides a technology for reducing emissions and offers a feasible method on emission control from fumigation for high-valued crops.

Indicator 2:

During 2008, ARS will 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.

FY 2008 Accomplishments:

1. The agricultural industry has adopted a “high dose/refuge strategy” as a means of delaying insect resistance to transgenic crops [such as ones that carry toxin genes from the bacterium *Bacillus thuringiensis* (Bt)]. However, recent transgenic corn products developed for control of western corn rootworm (WCR), have been introduced which are less than high-dose. ARS scientists reared a WCR, using a greenhouse method, on Bt-corn and survivors were mated to produce the next generation. The results suggest that a rapid response to selection is possible in the absence of mating with unexposed beetles, emphasizing the importance of effective refuges for resistance management.

Impact: This information will be important to seed companies, the Environmental Protection Agency (EPA), and system modelers in their attempts to update resistance management plans for transgenic rootworm-resistant corn.

2. ARS scientists determined that changes in the developmental rate of European corn borer (ECB) larvae may result from assortative mating (i.e., when organisms tend to mate with individuals that are like themselves in some trait, thus decreasing variation in that trait) and faster development of resistance to Bt-corn. ECBs resistant to Bt-corn may escape insect resistance management if they are infected with the microsporidium *Nosema pyrausta*. This

insect pathogen causes increased mortality, which is good, but it also causes developmental delays, which increase the chances of mating with similar individuals.

Impact: These results are relevant to government regulators and scientists interested in delaying ECB resistance to Bt-corn. Furthermore, this information is pertinent to scientists studying any insect that is targeted by genetically engineered crops.

Indicator 3:

During 2008, ARS will continue to develop fundamental knowledge about insect biology and ecology that provides the foundation for strategies to exclude, detect, and mitigate pest infestations.

FY 2008 Accomplishments:

1. Western flower thrip is a quarantined pest in Taiwan, and exported lettuce to Taiwan often harbors western flower thrips and therefore requires quarantine treatments. In pallet tests conducted by ARS scientists, ultralow oxygen (ULO) treatments achieved complete control of thrips in pre-treatment storage and prevented injury to lettuce heart leaves. The large-scale pallet tests further demonstrated efficacy and safety of the storage-ULO treatment combination for controlling western flower thrips on head lettuce. The protocols developed for the pallet tests may also be applicable to industry development of ULO treatment and controlled atmosphere storage of fresh commodities.

Impact: The ULO treatments have good potential to be developed into a safer and effective alternative to traditional fumigation for control of quarantined pests on fresh commodities and are also compatible with organic products.

2. Western flower thrip is a quarantined pest in Taiwan. Exported produce to Taiwan often harbors western flower thrips and therefore requires quarantine treatments. A commercial-scale fumigation trial using pure phosphine in a reefer container was conducted successfully by ARS scientists in collaboration with industry. Pure phosphine fumigation was demonstrated to be effective in controlling western flower thrips and safe on all of the commodities tested.

Impact: This research provides an effective solution to western flower thrips control on exported fresh commodities to Taiwan and benefits U.S. agriculture.

3. A literature review was completed and data set analyzed for evaluating grapefruit as a host for *Anastrepha obliqua*, the West Indian fruit fly. ARS scientists developed a new approach that uses analysis of life tables to evaluate survival of the stages of development of eggs and larvae of the fly in the peel and pulp tissues. Results showed that egg mortality, due to inability of the females to oviposit below the oil glands, and most larval mortality occurred in the albedo tissue of the peel. Larvae that burrowed into the pulp had high survival to produce pupae and adults.

Impact: Results from those species and the Mexican fruit fly showed that in Texas, grapefruit are very poor hosts, with eggs and larvae having nearly 100 percent mortality before February 15, but after April 1 Mexican fruit fly readily utilizes the fruit.

4. Regulatory agencies require a chemical treatment of hay exported to China to prevent accidental introductions of insect pests. Tests were conducted by ARS scientists that showed a phosphine and carbon dioxide gas mixture provides a high level of control of

Hessian fly puparia at low temperatures, and may be efficacious for a general sanitation treatment.

Impact: A general proposal was presented to China to consider this treatment in partial fulfillment of import requirements. This research targets greater U.S hay exports.

5. ARS scientists are working to adapt the successful embryo cryopreservation (freeze-drying) protocol for flies for use with various moth species. With this objective, pink bollworm moth embryos have been cryopreserved with a hatching rate of up to 20 percent.

Impact: This preliminary success with cryopreservation of a moth indicates that the numerous species and strains being maintained by ARS laboratories can be protected from accidental loss and that mass rearing facilities, such as the one operated by USDA-APHIS in Phoenix, Arizona, for control of pink bollworm, can maintain back-up colonies at minimal cost.

6. ARS scientists have sequenced the first beetle, *Tribolium castaneum* (red flour beetle), which thus joins the ranks of other fully sequenced “model organisms” such as the *Drosophila* fruit flies and the honey bee. The work is reported in the March 27 issue of the journal *Nature*. This accomplishment was largely due to the efforts of ARS scientists with collaborators at Kansas State University and the Baylor College of Medicine. The red flour beetle is a significant pest of stored grain and grain products worldwide, and the most important insect pest in flour mills. It can survive on a wide range of foods, including cornmeal, nuts, crackers, cake mix – even chocolate.

Impact: The sequenced genome provides clues to help in thwarting this important agricultural pest. Gaining insight into this beetle’s ability to establish resistance to many classes of insecticide could open new doors to insect pest management strategies in general.

Indicator 4:

During 2008, ARS will continue to develop fundamental knowledge about weed biology and ecology that provides the foundation for strategies to exclude, detect, and mitigate weed infestations.

FY 2008 Accomplishments:

1. Cooperative research with the University of Florida has yielded new information on the use of soil solarization and fumigants including iodomethane (Midas™ iodomethane:chloropicrin, 50:50, 224 kg/ha) under metalized films as an alternative to methyl bromide for soil fumigation. Four field trials were performed under both commercial and experimental field conditions in three locations in Florida. Pest pressure varied according to location and ranged from high nematode and weed pressure, to low nematode, but high weed pressure. Cut-flower crops evaluated were Celosia (*Celosia argentea*) and snapdragon (*Antirrhinum majus*). Low rates of methyl bromide (67:33 mbr:chloropicrin 200 lb/a) under metalized film did not provide good weed control.

Impact: Midas applied under metalized film provided weed control comparable to high rates of methyl bromide (98:2 400 lb/a) under high density polyethylene film, and lower rates of methyl bromide (98:2 200 lb/a) under metalized film. Soil solarization provided better control of white clover (*Trifolium repens*), a hard-coat weed not well controlled by methyl bromide, than any fumigant tested.

2. Evaluation of emerging new herbicides for weed control requires knowledge and information on potential phytotoxicity on crops. In field trials carried out by ARS scientists in California, unlabeled herbicides provided weed control in perennial crop field nurseries equal to or better than currently used herbicides with similar crop safety. Pre-emergence herbicides, rimsulfuron and flumioxazin, were safer on prunus rootstock planted as hardwood cuttings as compared to seeded rootstock cultivars.

Impact: The research findings identify potential methyl bromide alternatives for weed control in field nurseries.

Indicator 5:

During 2008, ARS will continue to develop fundamental knowledge about plant disease biology and ecology that provides the foundation for strategies to exclude, detect, and mitigate disease outbreaks.

FY 2008 Accomplishments:

1. The fungal species *Alternaria* is important in many crop disease and new species have yet to be identified and described. Two new *Alternaria* species were described from sunflower seeds and Australian navel oranges. ARS scientists found that these newly published species descriptions contribute incrementally to the list of known species and in the case of navel oranges, describe a new disease of imported navel oranges.

Impact: This information will be useful for plant quarantine regulatory agencies and to other scientists.

Measure 4.2.3 Summary of the Major Technologies Developed, Transferred, and Used in

FY 2008:

During FY 2008, ARS reported three 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	Describe the Transfer	Identify the Customer	Impact
A multiplex real time PCR assay was developed for the simultaneous detection of citrus tristeza virus (CTV), <i>Spiroplasma citri</i> (the casual agent of citrus stubborn disease), and huanglongbing (HLB)-associated disease. This multiplex quantitative PCR assay was developed by ARS scientists and is capable of simultaneously detecting the HLB-associated disease, as well as citrus stubborn and tristeza, in any combination of singleplex,	The California HLB Task Force developed an Action Plan for HLB to deal with/respond to the appearance of the Asian citrus psyllid and the HLB disease in California. The Action Plan, which details required California Department of Food and Agriculture (CDFA) inspections and restrictions on nurseries, includes a section on diagnostics related to detection, identification, and differentiation of the bacterium based on this	Citrus growers and other citrus industry groups (California Citrus Quality Council and Citrus Mutual), representatives of the CDFA, and APHIS.	Application of this procedure has potential to develop new information on strains of tristeza and distribution of stubborn wherever HLB surveys are taken and can play a role in detection and delimiting surveys for these pathogens.

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<p>duplex, or triplex from extracts made from citrus tissues. California has begun monitoring citrus for the presence of the Ca. <i>Liberibacter asiaticus</i>-associated huanglongbing (HLB) in dooryards and commercial fields.</p>	<p>technology.</p>		
<p>A valuable new germplasm of sugarbeet with disease resistance to <i>Aphanomyces</i> was released to the three sugarbeet seed companies. Seedling damping off and mature plant root rot is caused by the <i>Aphanomyces</i> species and is a primary limiting factor in sugarbeet stand establishment and yield.</p>	<p>A germplasm release was completed in 2008 and seed was distributed to sugarbeet seed companies for development into specific cultivars.</p>	<p>Sugarbeet seed companies and growers.</p>	<p>This is a critical source of resistance to an important disease. Incorporation of this germplasm into cultivars suited to regional needs serves to reduce pesticides used and increase stand establishment and yield.</p>
<p>ARS researchers have developed fumigation methods that significantly reduce effective application rates and unwanted atmospheric emissions for fumigant alternatives to methyl bromide. These methods improve the efficacy of the fumigants, but also require less fumigant thereby reducing the costs to farmers and also greatly reducing the deleterious environmental impacts of fumigant escaping from the soil.</p>	<p>To aid the transfer this technology to farmers, an apparatus was designed and constructed to simulate calibration and operation of fumigation application equipment in an instructional setting using water instead of chemical fumigants. The simulator was used in regional education programs conducted across the southeastern United States and subsequently expanded into a 2-day regional workshop conducted at the University of Georgia – Tifton Campus to train cooperative extension faculty on the application of methyl bromide alternatives.</p>	<p>Extension faculty from Auburn University, Clemson University, North Carolina State University, the University of Georgia, and the University of Florida were trained in this new methodology so that they could train farmers in their respective states.</p>	<p>This technology will speed the transition to methyl bromide alternatives by making the alternatives more cost-effective and more environmentally acceptable.</p>

Measure 4.2.3 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

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

will 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.

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

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

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

During FY 2010, ARS will

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

will 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.

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

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

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

During FY 2011, ARS will

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

will 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.

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

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

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

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.

Baseline 2006

Developed and implemented strategies for management of key invasive pest species, such as the Asian longhorned beetle, leafy spurge, melaleuca, glassy-winged sharpshooter, whiteflies, and other species. Provided data in support of industry needs, APHIS and other action agencies. Conducted Areawide pest management programs for five insects and weeds. Increased systematic capabilities for fungal, bacterial and viral plant diseases and insect pests. Developed data for use in risk analyses of biological control agents, particularly with regard to modeling prediction of risk and protection of non-target species. NAL continued to operate www.invasivespeciesinfo.gov.

Target 2011

Improve knowledge and understanding of the ecology, physiology, epidemiology, and molecular biology and genomics of endemic and emerging diseases and pests. Incorporate this knowledge into at least 10 management strategies to minimize chemical inputs and increase production. Expand systematics of arthropods, fungi, and other biological collections' infrastructure.

Indicator 1:

During FY 2008, ARS will continue to develop and demonstrate technologies, including risk analysis, for excluding, detecting, and mitigating native and invasive insect pests, integrated pest management (IPM) and areawide approaches, and deliver IPM components and systems to ARS customers.

FY 2008 Accomplishments:

1. ARS successfully implemented four new 5-year AWPM projects that included management of (a) weedy annual grasses on rangelands (Burns, Oregon), (b) the Asian tiger mosquito, a vector of West Nile virus (Gainesville, Florida), (c) navel orangeworm on nut trees (Parlier, California), and (d) a national effort for management of honey bee parasites and diseases, and improved honey bee health, survival, and pollination. Partnership teams consisting of Federal, State, and the private sector have been established for each project, with demonstration sites and economic and environmental assessments implemented.

Impact: Each project has incorporated a proven technology package that is projected to save customers millions of dollars of savings when the technologies are fully adopted over the 5-year period.

2. In the winter months, it was previously believed that boll weevils entered a form of hibernation or dormancy called diapause. But ARS researchers have found that these insects generally remain active during winter in the subtropics, surviving by feeding on the edible portion of

orange, grapefruit, and prickly pear cactus, and possibly other plants. Orange and grapefruit can sustain adult boll weevils for as long as 8 months – more than enough to see them through the mandatory cotton-free winter period. This research is of importance to the Boll Weevil Eradication Program run by APHIS in that it will help development of new, biological and ecological approaches to controlling the weevils. Most of the new proposed tactics do not rely on insecticide use, and the one that does ensures that insecticides would be applied when most effective.

Impact: The program, overall, has enabled cotton farmers to reduce their use of pesticides by between 40 and 100 percent, and increase their cotton yields by at least 10 percent.

3. The production of a soil-stable, infective propagule of *Metarhizium anisopliae* is needed for control of soil-dwelling insects. ARS researchers were able to produce an environmentally-resistant form (called a microsclerotia) of the fungus in liquid culture. These preparations of *M. anisopliae* survived air-drying (<5 percent moisture) with no significant loss in viability and germinated to produce both hyphae and infective spores when rehydrated in soil. Bioassays using air-dried microsclerotia preparations resulted in significant infection and mortality in larvae of the sugarbeet root maggot.

Impact: This is the first report of the production of sclerotial bodies by an insect-pathogenic fungus and provides a novel approach for the control of soil-dwelling insects with this fungus.

4. Parasitoid wasp viruses called polydnviruses that are injected by the host wasp when it lays its eggs in a caterpillar host may be useful for biological control of caterpillars; however, the viruses have not been well characterized to date. In collaboration with scientists from the Institute for Genomic Research (TIGR) in Rockville, Maryland, ARS scientists obtained full complex viral genome sequences from two polydnviruses. New discoveries were made; e.g., a new family of virus-encoded genes was discovered that has not been found associated with other polydnviruses and may have been acquired from its host wasp genome.

Impact: This new information will lead to better understanding of the virus replication system, its evolution, and should lead to improved wasp selection for insect biological control.

Indicator 2:

During 2008, ARS will 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.

FY 2008 Accomplishments:

1. Herbicide sensitivity is considered the most serious pest management issue for sweet corn growers in North America. ARS scientists participated in team research that determined that a single recessive gene (or very closely-linked genes) made corn more sensitive to 11 herbicides spanning five unique modes of action. Furthermore, all 12 major sweet corn breeding programs carry the sensitivity allele. Given the ubiquitous production of corn in the United States, advancement in this field has broad, large-scale impact. Technology transfer has been initiated through four technical bulletins, which have become the primary source for growers and industry to determine hybrid sensitivity.

Impact: The herbicide manufacturing industry can better determine which germplasm to use for identifying herbicide use rates and corn breeding programs are now using this genetic basis in their approach to enhance tolerance to herbicides.

2. Yellow starthistle (YST) is a serious weed of Western rangelands, infesting over 10,000 hectares in the state of California alone. ARS scientists, in cooperation with the California Department of Food and Agriculture (CDFA) Biological Control Program, have released the fungus, *Puccinia jaceae*, on YST populations in 41 counties in California. The fungus established and survived into a second season at more than 30 locations, and substantial spread (more than 30 meters) has been noted at some release sites. Field monitoring has established that field-inoculated plants are damaged by the infections. In 2008, the Animal and Plant Health Inspection Service (APHIS) approved a permit application by the Oregon Department of Agriculture (ODA) for release of the fungus into the state for biological control of YST and inoculum was supplied to ODA for the releases.

Impact: The project demonstrates the potential for the fungus to reduce YST populations in concert with established natural enemies and integrated weed management practices.

Indicator 3:

During 2008, ARS will 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.

FY 2008 Accomplishments:

1. Accurate disease forecast is essential for timely management of the economically limiting disease of wheat. In 2008, ARS scientists conducted long-, mid-, and short-term forecasts for stripe rust epidemics using weather data, disease monitoring data, and cultivar resistance. Stripe rust alerts were sent to growers as early as February and throughout the growing season. As a result of the accurate forecasting, timely alerts, and advice for choosing resistant cultivars and decision support for use of fungicides, wheat growers implemented appropriate measures for stripe rust control. Major yield losses for the hard red winter wheat growing regions in Washington were prevented and multimillion dollar savings were realized by preventing unnecessary use of fungicides in many other regions. In addition, these scientists identified new races of the stripe rust fungus. Like many other pathogens, the stripe rust fungus is able to evolve into new virulent races that can circumvent genetic resistance in wheat and barley cultivars. Predominant stripe rust races were identified from samples collected throughout the United States in 2007. ARS researchers identified 11 new races; some of which are able to overcome resistance conferred by the resistance gene currently used in many wheat breeding programs. Information was sent to breeding programs with a warning not to use that gene alone.

Impact: The finding of such new races will guide breeding programs to use durable type of resistance and/or combinations of effective major resistance genes to develop cultivars with durable resistance to stripe rust.

Measure 4.2.4 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS reported improved knowledge and understanding of ecology, physiology, epidemiology, and molecular biology and genomics of endemic and emerging diseases and pests; incorporated this knowledge into at least two management strategies that were developed and implemented to minimize chemical inputs and increase production.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
The genetic source of herbicide sensitivity, the most serious pest management issue for sweet corn growers in North America, was identified by ARS scientists and their collaborators. The researchers determined that a single recessive gene (or very closely-linked genes) made corn more sensitive to 11 herbicides spanning five unique modes of action. Furthermore, all 12 major sweet corn breeding programs carry the sensitivity allele.	This information has been transferred through four technical bulletins, which have become the primary source for growers and industry to determine hybrid sensitivity.	Corn breeders and growers and herbicides producers.	As a result, the herbicide manufacturing industry can better determine which germplasm to use for identifying herbicide use rates, and corn breeding programs are now using this genetic basis in their approach to enhance tolerance to herbicides. Given the ubiquitous production of corn in the United States, advancement in this field has broad, large-scale impact.
ARS scientists and collaborators completed the genomic sequencing of the <i>Tribolium castaneum</i> (red flour beetle), a significant pest of stored grain and grain products worldwide, and the most important insect pest in flour mills.	The work was reported in the March 27, 2008 issue of the journal <i>Nature</i> .	Grain and food industry producers.	The sequenced genome provides clues to help thwart this important agricultural pest, and provide insight into this beetle's ability to establish resistance to many classes of insecticide, opening new doors to insect pest management strategies in general.

Measure 4.2.4 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

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

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.

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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.

During FY 2010, ARS will

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

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.

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.

During FY 2011, ARS will

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

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.

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.

Measure 4.2.5 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.

Baseline 2006

Developed and implemented five strategies for exclusion, detection, and eradication of quarantine pests and pathogens. Provided data in support of needs of industry, APHIS, and other action agencies. New technologies developed and implemented by action agencies that have opened new export markets.

Target 2011

Improved knowledge and understanding of quarantine pest and pathogen biology and epidemiology, leading to 30 new technologies implemented by industry, APHIS, 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.

Indicator 1:

During FY 2008, ARS will continue to develop diagnostic assays to detect and differentiate existing, new and/or emerging quarantine arthropod pests, weeds, nematodes, and pathogens.

FY 2008 Accomplishments:

1. California has begun monitoring citrus for the presence of the the three economically limiting diseases: Citrus tristeza virus (CTV), citrus stubborn, and Huanglongbing (HLB), also known as citrus greening. A sensitive molecular assay was developed by ARS scientists capable of simultaneously detecting HLB, as well as citrus stubborn disease and CTV, in any combination from extracts made from citrus tissues.

Impact: This important new assay provides timely information on the presence of three important citrus pathogens, thus saving time and money, and will be deployed as part of the CTV eradication program.

2. Barley and cereal yellow dwarf viruses (B/CYDVs), wheat spindle streak mosaic (WSSMV), soil-borne wheat mosaic virus (SBWMV), and wheat streak mosaic virus (WSMV) constitute the most economically important group of wheat viruses, but methods to identify specific viruses have not been available. ARS researchers have developed a highly specific and sensitive molecular assay that identifies multiple grain viral pathogens based on their DNA sequence. Using this method the epidemiological basis of these viral diseases is being elucidated through the analysis of samples from Indiana, North Carolina, Arkansas, Georgia, and Missouri. The results have shown that most infections consist of two to four barley and cereal yellow dwarf viruses and have clearly demonstrated that wheat streak mosaic virus, soil-borne wheat mosaic virus, and wheat spindle streak mosaic virus also are important pathogens in the eastern U.S. wheat-growing region. Previously, WSMV was thought to be primarily confined to more arid wheat production areas.

Impact: This information will be critical in developing wheat, barley, and oat lines that are resistant to an array of viral pathogens. Because of the utility and sensitivity of this method, plant pathogen diagnostic laboratories in six states are adopting this technology as a primary virus diagnostic test. These new methods are providing critical information to plant pathologists and plant breeders that will enable them to develop integrated strategies to reduce the economic impact of these diseases.

Indicator 2:

During 2008, ARS will continue to expand interdisciplinary research to include means of excluding, managing and/or eradicating quarantine arthropod pests, weeds, nematodes and pathogens.

FY 2008 Accomplishments:

1. Phantom® is a new insecticide that specifically targets insect metabolism, and is registered to control termites, cockroaches, and ants. If this chemical could be registered to control stored-product insects inside facilities where processed food is stored, it would enable the use of an insecticide that would be of limited risk to humans. ARS scientists conducted tests by exposing adult red flour beetles and confused flour beetles on concrete, tile, and plywood surfaces treated with Phantom®. The insecticide was more effective on concrete compared to tile and plywood, and the red flour beetle was more susceptible than the confused flour beetle. Most beetles died within 1-7 days after they were exposed on the treated surfaces. Results show that this insecticide can be incorporated into management plans for stored-product insects in food processing facilities, and the insecticide label is being amended to include control of these insects.

Impact: Results show that this insecticide can be incorporated into management plans for stored-product insects in food processing facilities, and the insecticide label is being amended to include control of these insects.

2. Dragon fruit is a host of fruit flies found in Hawaii and therefore is subject to quarantine restrictions when shipped to the U.S. mainland. ARS scientists established that irradiation treatment of dragon fruit at doses at or below 800 Gy would ensure visual and compositional quality while providing quarantine security against fruit flies.

Impact: This research will support the rapid adoption of APHIS' recently passed rule and expand high value specialty fruit exports from Hawaii with subsequent benefit to Hawaiian agriculture.

Indicator 3:

During 2008, ARS will apply essential taxonomy and systematics for organisms toward the correct identification and diagnosis and control of target arthropod pests, weeds, nematodes, and pathogens.

FY 2008 Accomplishments:

1. Viruses are very simple infectious agents, most of which are composed of DNA or RNA, and a protective coat protein. Potato leafroll virus (PLRV) has two structural proteins that make up its protective coat protein. The minor protein is multifunctional and is known to play a role in spread of the virus both within plant hosts and between plants by insect vectors. ARS scientists determined how this protein works and have defined what parts of the protein are responsible for different functions. One end of the protein is responsible for restricting the

virus to plant vascular tissues, a novel finding that is a first for virology. Furthermore, in this capacity this protein functions as a soluble rather than structure protein. When the protein is incorporated into the shell of the virus, another part of the protein is required for the virus to be transmitted by its insect vectors.

Impact: Understanding how a virus moves within and between plants provides potential targets for novel control strategies.

2. Specific amino acid positions in the HC-Pro (helper component-protease) protein of wheat streak mosaic virus are critical for mite transmission of the virus. The helper component protein is required for transmission by aphids of many viruses in the family Potyviridae. Wheat streak mosaic virus (WSMV) is transmitted by mites and belongs to the same group of Potyviruses. Mutations introduced into the HC-Pro coding region of wheat streak mosaic virus were evaluated by ARS scientists for systemic infectivity to wheat and vector transmission by the wheat curl mite. Specific amino acid mutations in this protein were identified and shown to be necessary for virus transmission by the wheat curl mite. Mutation at other positions had no effect on vector transmission or resulted in reduced vector transmission efficiency. Results provide direct evidence that vector transmission of WSMV requires a specific site in the HC-Pro.

Impact: This research provides new information on molecular basis of mite transmission of WSMV, and may ultimately be useful in blocking virus transmission by mites.

3. Rush skeletonweed now occupies about 2.5 million hectares of land in the northwest United States. It is a threat to irrigated lands, dry-land cropping areas, and rangelands. The weed is also starting to invade natural forests, outcompeting native plants for nutrients. The current biological control agents do not work on all biotypes of the species. ARS scientists researching the weed's genealogy, determined that there are seven genotypes of rush skeletonweed in all of North America.

Impact: This information will help with selecting and testing new biological control agents and determining where to use them.

4. In support of USDA-APHIS, ARS scientists reported over 13,000 identifications in FY 2008, of which 6,900 were considered urgent. ARS systematists also: determined that the invasive weed *Arundo donax* (giant reed) is a host for a major pest of sugarcane; discovered in the Dominican Republic a leafhopper known to be a vector of lethal yellowing disease of palms; reported that the European leaf-miner fly, a pest of broccoli and related crops, was found in the United States; and determined that flies are pollinators to many flowering plants including, mango, cashew, strawberries, and apples. In addition, the researchers completed several papers and book chapters that are used for insect identification in the United States and worldwide including a completed a catalog of aphids that are serious pests of agricultural importance, a book chapter on true bugs that discusses their importance as pests and predators, and an illustrated key to the longhorned woodboring beetles of the eastern United States.

Impact: This supports APHIS' efforts to protect the Nation's borders from invasive insects.

Indicator 4:

During 2008, ARS will 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.

FY 2008 Accomplishments:

1. The exotic pathogen *Phytophthora ramorum* is responsible for extensive mortality of oaks and tanoaks, as well as economic losses to U.S. nurseries due to its infection of common ornamental plants. *P. ramorum* exists as three distinct clonal lineages and it is not clear if they originate from the same, possibly sexually reproducing population of unknown origin. ARS scientists found that the lineages have been diverged for at least 11 percent of their history, an evolutionarily significant amount of time estimated to be on the order of 165,000 to 500,000 years.

Impact: The divergence of the three clonal lineages of *P. ramorum* supports a scenario in which the three lineages originated from different geographic locations that were sufficiently isolated from each other to allow independent evolution prior to introduction to North America and Europe.

2. ARS scientists have isolated and functionally characterized a chorismate mutase gene that encodes a secreted protein from the golden nematode, an important pest of potato. Importantly, it was discovered that the activity of this secreted protein is controlled by a novel mechanism that has never been reported for any plant-parasitic nematodes. Furthermore, this study found that the chorismate mutase protein is linked to a novel form of nematode resistance in potato.

Impact: Understanding the function of nematode secretions will accelerate the development of novel nematode control strategies.

3. Zebra chip, a new and emerging potato disease, is causing millions of dollars in losses to potato producers and processors in the southwest of the United States, Mexico, and Central America. ARS researchers demonstrated for the first time that zebra chip is associated with the potato psyllid, *Bactericera cockerelli*. In addition, in collaboration with other ARS and university scientists, an integrated pest management program was developed for the management of this insect pest to reduce incidence of zebra chip.

Impact: Growers in the Lower Rio Grande Valley of Texas have recently managed to keep zebra chip incidence under manageable levels by applying insecticides targeted against the potato psyllid.

Indicator 5:

During 2007, ARS will support interagency collaboration for tracking successful exclusion, eradication where possible, and management of quarantine arthropods, weeds, nematodes, and pathogens.

FY 2008 Accomplishments:

1. Huanglongbing (HLB) disease of citrus, also known as citrus greening, represents the most serious threat that the U.S. citrus industry has encountered. The disease is associated with a bacterium, *Candidatus Liberibacter* spp, which has not yet been isolated in pure culture. Sequencing of ribosomal RNA genes of the bacterium facilitated development of an improved PCR assay for detection of the bacterium by ARS scientists.

STRATEGIC GOAL 4

Impact: The assay will be useful in studies designed to evaluate the association of the bacterium with HLB disease.

Measure 4.2.5 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS reported improved knowledge and understanding of quarantine pest and pathogen biology and epidemiology, leading to two 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	Describe the Transfer	Identify the Customer	Impact
<p>A new invasive "orange rust" fungus was identified on sugarcane in the United States by ARS scientists. Sugarcane is an important crop that is threatened by a number of plant diseases caused by fungi. One of these fungi, <i>Puccinia kuehnii</i>, is a rust that causes a disease of sugarcane in Asia and Africa; however, until recently, it was not known to occur in the continental United States. This rust fungus has been found to be present in Florida infecting cultivars of sugarcane that were resistant to the other common "brown rust" fungus. DNA sequences and morphological features were used to identify <i>P. kuehnii</i>.</p>	<p>New knowledge of this serious threat to the sugarcane industry was transferred through publications, national/international conference calls, and meetings.</p>	<p>Researchers, sugar cane growers, and regulatory agencies.</p>	<p>This information is being used by plant pathologists to identify the rust fungus causing disease on sugarcane, as well as by sugarcane breeders and producers to determine which cultivars of sugarcane should be planted and to develop cultivars with desirable resistance.</p>
<p>Development and use of a rapid virus detection method for small grains viral pathogens. This detection method will provide critical information for plant pathologists and plant breeders to develop integrated strategies to reduce the economic impact of these diseases. Using this method, the epidemiological basis of these viral diseases is being elucidated through the analysis of samples from Indiana, North Carolina, Arkansas, Georgia, and Missouri. The results have shown that most infections consist</p>	<p>Published methods in scientific journals, and partnered with plant pathogen diagnostic laboratories in six states.</p>	<p>Plant pathologists and plant breeders who will be able to develop integrated strategies to reduce the economic impact of these diseases.</p>	<p>Because of the utility and sensitivity of this method, plant pathogen diagnostic laboratories in six states have adopted this technology as a primary virus diagnostic test.</p>

of two to four barley and cereal yellow dwarf viruses and have clearly demonstrated that wheat streak mosaic virus, soilborne wheat mosaic virus, and wheat spindle streak mosaic virus also are important pathogens in the eastern U.S. wheat growing region. Previously wheat streak mosaic virus was thought to be primarily confined to more arid wheat production areas. This information will be critical in developing wheat, barley, and oat lines resistant to an array of viral pathogens.

Measure 4.2.5 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

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

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

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

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.

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

During FY 2010, ARS will

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

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

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

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.

STRATEGIC GOAL 4

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

During FY 2011, ARS will

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

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

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

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.

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

Strategic Goal 5:

Improve the Nation's Nutrition and Health

Improving the Nation's health requires improving the quality of the American diet. The United States is experiencing an obesity epidemic resulting from multifaceted causes including sedentary lifestyles, selection of readily available high calorie foods, and increasing portion sizes. In addition, 4 of the top 10 causes of death in the United States—heart disease, cancer, stroke, and diabetes—are strongly associated with the quality of our diets—diets too high in calories, saturated fat, sodium, and added sugars, and too low in fiber rich foods such as fruits, vegetables, and whole grains. There is an increasing demand for foods that taste good, are convenient, economical, and yet offer nutrition and health benefits. Building a strong connection between agriculture and human health is an important step to providing a nutritionally enhanced food supply. Promoting healthier food choices and educating Americans to balance caloric intake with sufficient daily physical activity are vital steps to preventing obesity and decreasing risk for chronic diseases.

ARS conducts research to identify nutritive and health promoting components in foods, improve the understanding of human nutrient requirements at all stages of the life cycle, and better understand the relationships between diet and health. The Agency also determines the composition and bioavailability of beneficial components in foods, conducts the national "What We Eat in America" food consumption survey to track the nutritional quality of the American diet, and conducts research on dietary interventions and strategies for modifying diets, food choices, and physical activity behaviors. The outcomes of these combined research efforts provide a scientific knowledge base to evaluate the healthfulness of the American diet and food supply, and to establish sound dietary recommendations for Americans, such as the Dietary Reference Intakes and the USDA/HHS Dietary Guidelines. The information is widely used by policymakers, Government agencies, industry, and educators to promote better diets, reach children early, and enable people to make healthful food and lifestyle choices.

OBJECTIVE 5.1: ENSURE ACCESS TO NUTRITIOUS FOOD

Activities related to this objective are primarily carried out by other USDA agencies.

OBJECTIVE 5.2: PROMOTE HEALTHIER EATING HABITS AND LIFESTYLES

The prevalence of obesity in the United States has doubled during the past two decades, making it a critical public health problem. High quality research is required to address this multifaceted problem. Good health is dependent on adequate physical activity combined with consumption of foods with the right balance of nutrients to meet an individual's needs within caloric requirements.

Building databases of food composition is critical to developing healthy diets. Also important is improving the health promoting value of foods through selection, biotechnology, processing, and other practices. ARS research will monitor food consumption patterns of Americans across time, define ways to prevent obesity (particularly in minority populations who are particularly susceptible to this condition) improve health through dietary manipulation, and help establish optimal levels of nutrients/foods to maximize health.

Performance Measures

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.

Baseline 2005

Three food intake and nutrient content databases released by ARS and used by ARS customers to establish Federal dietary policy guidelines, food assistance and feeding programs, and food labeling to safeguard the health of the American people. Also, NAL continued to operate nutrition.gov.

Target 2011

Cumulatively, 25 new databases developed and released to ARS customers.

Indicator 1:

During FY 2008, ARS will survey, release data on, and analyze national food consumption patterns of Americans.

FY 2008 Accomplishments:

1. Data for 2005-2006 were released from the What We Eat in America/NHANES survey. This is the only nationally representative survey of what foods and nutrients Americans are eating.

Impact: Federal nutrition policy, estimates of safe and adequate intake of nutrients (Dietary Reference Intakes) established by the Institute of Medicine, and estimates of exposure to pesticides calculated by the HHS, Environmental Protection Agency are examples of programs that require accurate and nationally representative dietary survey information. In addition, this database is widely used by researchers at universities who analyze the data for correlations with indicators of health and disease to predict healthy dietary patterns.

2. Version 3.0 of the Food and Nutrient Database for Dietary Studies was released and includes more than 13,500 foods, nutrients, and typical portion sizes.

Impact: This database is used for the What We Eat in America/NHANES national dietary survey and by the USDA's Center for Nutrition Policy and Promotion as the foundation of the MyPyramid individualized nutrient intake calculations. The Web site hosting MyPyramid is one of the most widely accessed Federal Web sites.

Indicator 2:

During 2008, ARS will develop new methods, conduct food composition analyses, and compile databases for known, emerging, and new classes of nutrients.

FY 2008 Accomplishments:

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

Impact: The primary product of this research is the unique, nationally representative information on nutrient content of the food supply and what Americans are eating in order to assess their food consumption in relation to dietary recommendations designed to maintain health and prevent chronic diseases.

Measure 5.2.1 Summary of the Major Technologies Developed, Transferred, and Used in

FY 2008:

During FY 2008, ARS reported four 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	Describe the Transfer	Identify the Customer	Impact
Release 21 of the USDA National Nutrient Database for Standard Reference was compiled and released to the public. Up to 160 nutrients in over 7,500 foods are included.	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.	This database is widely used by USDA's REE and FNS agencies and by other Federal agencies such as FDA's food labeling program. Individuals and health professionals make use of this information.	This database is widely used by researchers, health professionals, businesses that produce diet analysis software, and the public in planning and evaluating diets. In addition, it is used by USDA's REE and FNS Agencies for research, evaluating food assistance programs, and policy formulation.
The USDA Database for Choline Content of Common Foods, Release 2 was released. Values for more than 600 foods are included and the betaine content of grains was made more accurate in this revised release.	This dataset was made freely available via the Internet.	Users include health professionals, researchers, and members of the public interested in this nutrient.	This dataset was updated to increase the number of foods included and to more accurately reflect the content of the related nutrient, betaine. More accurate food information on choline/betaine content improves the accuracy of choline and health research studies.
Release 2.0 of the USDA Database for the	This dataset was made freely available via the	The primary users of this dataset are academic	Isoflavones are plant estrogens found in

<p>Isoflavone Content of Common Foods was compiled and released. A number of values were updated and new foods were added to total more than 550.</p>	<p>Internet.</p>	<p>researchers and health professionals. In addition, individuals interested in consuming more healthful diets can use this to select foods high in isoflavones.</p>	<p>legumes, especially soybeans and have been shown to have a number of healthful effects, including strengthening bone, reducing risk of cancer and heart disease. More accurate information on these compounds in foods allows better choice of diets and more accurate research studies.</p>
<p>Version 3.0 of the What's in the Foods You Eat Search Tool was released.</p>	<p>This dataset was made freely available via the Internet. It can be run on the Web or downloaded to a personal computer.</p>	<p>This search tool and accompanying database is aimed primarily at consumers, although it is used by researchers also.</p>	<p>Because this release lists foods commonly eaten in familiar portion sizes that can be adjusted by the user, it is a consumer-friendly version of our more sophisticated databases. This makes the information more accessible to the public, without the need for detailed knowledge of food components or metric measurements.</p>

Measure 5.2.1 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

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

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

During FY 2010, ARS will

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

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

During FY 2011, ARS will

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

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

Measure 5.2.2 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.

Baseline 2005

Three Federal and Institute of Medicine reports used to establish Federal nutrition policy and regulations that employ ARS research results in formulating recommendations to safeguard the health of the American people.

Target 2011

Cumulatively, 23 new reports using ARS research to develop authoritative positions on nutrition and health issues.

Indicator 1:

During FY 2008, ARS will identify dietary and lifestyle intervention strategies to prevent obesity and promote healthy food choices and eating behaviors.

FY 2008 Accomplishments:

1. Scientists at the ARS nutrition center in Boston, Massachusetts, reported that following the *Dietary Guidelines for Americans* reduces the risk of metabolic syndrome by half in a study of over 3,100 people. Metabolic syndrome is a cluster of several risk factors for heart disease that are all tied to obesity including increased waist circumference, high blood pressure, elevated blood sugar, and raised blood lipids.

Impact: These results highlight the value of the *Dietary Guidelines for Americans* in mitigating the high incidence of obesity and reducing the risk for heart disease, the major cause of death in the United States.

2. Scientists at the ARS Center in Little Rock, Arkansas, found that resting brain electrical activity, a measure of brain development, did not differ between infants fed milk-based or soy-based formula during their first 6 months of life.

Impact: Soy infant formula contains phytoestrogens – chemicals with structures similar to estrogen. Several countries have banned soy formula based on concerns that these compounds pose a developmental risk to infants. These findings will help reduce parental and food industry concerns regarding the use of soy infant formula.

3. A research study conducted at the ARS nutrition center in Houston, Texas, identified an intensive, individualized healthy lifestyle program that was able to induce weight loss in overweight Mexican-American children.

Impact: Mexican-Americans, and other ethnic minorities are at increased risk of obesity and its unhealthy consequences. Development of effective interventions has been elusive

for the research community. This program has the potential for serving as an effective model in reducing obesity among minority children.

4. ARS scientists at Davis, California, reported that beverages sweetened with high-fructose corn syrup (HFCS) have the same metabolic effects as sucrose in volunteers consuming tightly controlled diets.

Impact: HFCS is regularly linked to obesity by the public and a small number of scientists; however, there has been an absence of data on this topic. The current study shows little difference between calories from HFCS or from table sugar, suggesting weight gain is linked to excess calorie intake and not a specific type of sweetener.

Indicator 2:

During 2008, ARS will determine the functions, bioavailability, interactions, and requirements for known, emerging, and new classes of nutrients across the lifecycles.

FY 2008 Accomplishments:

1. A study on effect of body size on the serum vitamin D response to oral supplements in healthy older adults was conducted at the ARS nutrition center in Boston, Massachusetts. It was found that subjects with higher Body Mass Index had lower vitamin D levels than thinner individuals given the same level of vitamin D intake.

Impact: The study implies that body size should be taken into account when estimating the amount of vitamin D required. An expert committee chartered by the Institute of Medicine is reevaluating the Dietary Reference Intake amounts for vitamin D so this study will be considered by the committee, which is expected to update the requirements in late 2010.

2. A growing body of evidence suggests that vitamin D may adversely affect the cardiovascular system but data from longitudinal studies are lacking. Scientists at the ARS Center in Boston, Massachusetts, followed 1739 people for about 5 years. Hypertensive individuals who were vitamin D deficient had a two-fold higher incidence of negative cardiovascular events than those who were not deficient. However, this effect was not found in those without hypertension.

Impact: With vitamin D deficiency prevalent among Americans, these findings have broad public health implications.

3. ARS scientists from Beltsville, Maryland, conducted a study in which volunteers ate all their calories for weight maintenance in either three meals or one meal per day over two months and measured a number of metabolic functions.

Impact: Subjects consuming one meal per day had elevated blood glucose before and after meals and the impaired glucose tolerance was reversible once three meals per day were eaten. These results give additional credence to the recommendation to consume three balanced meals per day.

4. Scientists at the ARS nutrition center in Houston, Texas, completed studies on volunteers who consumed a fermentable fiber called inulin for 8 weeks. Addition of inulin resulted in increased absorption of calcium from the intestine by more than a third.

Impact: This finding suggests that addition of specific types of fermentable fiber to the diet can improve calcium efficiency so that lower intake could meet the requirements. Because the increased calcium absorption occurs primarily in the colon, this could also be important for people who have impaired absorption from the small intestine.

Measure 5.2.2 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS reported three 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	Describe the Transfer	Identify the Customer	Impact
The Institute of Medicine's Food and Nutrition Board published a study on the Use of Dietary Supplements by Military Personnel. Information in this report used ARS dietary analysis methods to calculate military dietary information and compared it with that generated by ARS for the civilian population as part of the What We Eat in America /NHANES study.	The report and the database are available free via the Web or for purchase in hard copy from the National Academy Press.	The primary user is the Department of Defense (DoD).	Because of widespread use of dietary supplements by military personnel, formal assessment of the types and amounts of supplements was needed by the DoD. In addition, they monitor dietary supplement use to avoid adverse effects or interactions with medications.
The Low-Cost, Moderate-Cost, and Liberal Food Plans were published by the USDA Center for Nutrition Policy and Promotion. The plan provides representative healthful market baskets at three different cost levels. ARS food consumption data were used to create the three plans.	An 80 page report was published and made freely available via the Web.	The primary user group is nutrition and consumer educators.	This report documents that the recurrent claim that healthy eating is too expensive, simply is not accurate. The report assists educators and consumers in identifying healthful foods within appropriate budgetary constraints.
A series of reports from USDA Food and Nutrition Service (FNS) was released that examines the diet quality of Americans by participation in Food Stamp (now Supplemental Nutrition Assistance Program), Women Infants and Children (WIC), or School Lunch programs. ARS diet survey and nutrient database data were used to examine current and model diets.	These reports were prepared by researchers at Abt Associates and made available online by FNS	The primary user is the Food and Nutrition Service; secondary users are nutrition educators.	The major findings of these reports are that participation in Federal nutrition assistance programs was not associated with significantly lower consumption of recommended foods compared with the general population. However, several improvements in food group choices were identified that could improve diet quality of participants.

Measure 5.2.2 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

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

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

During FY 2010, ARS will

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

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

During FY 2011, ARS will

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

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

Measure 5.2.3 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.

Baseline 2003
Six research studies published in peer reviewed biomedical literature with the potential to strongly influence the field of human nutrition or have demonstrated impact through high citation rates.
Target 2011
Cumulatively, 30 new scientific papers will be published that generate high impact among the research community.

Indicator 1:

During FY 2008, ARS will publish new findings on metabolic processes that are affected by nutrient intake.

FY 2008 Accomplishments:

1. A study conducted by scientists at the ARS nutrition center in Boston, Massachusetts, found that the variability of the glycemic index (blood sugar response to a fixed amount of carbohydrate from different foods) within and between individuals was on the order of 40 percent, which is too great for it to be of use in making dietary recommendations.

Impact: The 2010 Dietary Guidelines Advisory Committee is currently meeting and reviewing glycemic index data to determine if it should be incorporated into dietary guidance. This information will help inform that decision.

2. Scientists at the Grand Forks nutrition center in North Dakota conducted a study in over 100 participants on absorption of zinc as influenced by the amount of zinc in the diet as well as a component of dietary fiber called phytate that inhibits mineral absorption.

Impact: There is concern that a sizable fraction of the U.S. population does not take in adequate zinc. This study suggests that absorption of zinc is more efficient from low-zinc diets so that the body can adjust to a low level but that high-phytate diets will prevent increased absorption at the lower level. Therefore, it is important to balance adequate mineral intake with foods that are rich in dietary phytate.

3. ARS scientists in Boston, Massachusetts, found that supplementing the diet of animals with strawberries increased the rate of new neuron growth in a brain region important to memory function.

Impact: Until recently, it was believed that brain cells (neurons) were lost throughout the lifespan and not replaced. Now we know that new neurons can be made but the rate slows with aging and that health-promoting chemicals in plants can intervene in this decline in brain function.

Indicator 2:

During FY 2008, ARS will discover genetic or epigenetic factors that influence physiologic responses to diet or changes in gene expression in response to dietary intake.

FY 2008 Accomplishments:

1. The ARS nutrition center in Boston, Massachusetts, found that variations in a single gene, designated PPARGC1A which is a master regulator of energy metabolism, among almost 1,000 Puerto Rican subjects in Boston are significantly associated with risk for diabetes, cardiovascular disease, and DNA damage. The activity of the identified gene variant can be increased as a result of exercise.

Impact: This study identifies a gene that markedly alters risk of two important diseases and a simple means of modifying that risk which is consistent with the physical activity guidelines from the Federal government.

2. Researchers from the ARS nutrition center in Houston, Texas, found that supplementation of nutrients providing methyl groups (choline, vitamin B12 and folate) to mice genetically prone to obesity prevented the tendency toward obesity over three generations.

Impact: Two important conclusions from this paper will affect thinking in the field of inherited tendency toward obesity. First, the change is not affected by the genes, but by epigenetic mechanisms such as methylation of DNA, and second, that this process can be interrupted by changes in diet that control the level of DNA methylation.

Measure 5.2.3 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS reported four new scientific papers 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	Describe the Transfer	Identify the Customer	Impact
A study led by an ARS scientist from the Grand Forks nutrition center found that one to five year-old children in Bangladesh at high risk for rickets who were supplemented with milk powder containing one of three levels of calcium showed no signs on rickets and normal bone formation after 13 months. The lowest level was one-tenth that normally recommended.	Publication in peer-reviewed biomedical literature.	The primary users are other researchers who will cite this work and build upon it. In addition, food aid agencies and organizations will use this information.	Federal agencies providing food aid to developing countries will reconsider the amount of calcium that should be added to supplemental foods for young children. In addition, these data may be used in reconsideration of the recommended amount of calcium for American children, which is being studied now by an expert committee for the National Academy of Sciences.
Maintenance of muscle mass while aging is important in preventing falls and fractures. Metabolic acidosis promotes muscle loss and diets that are rich in acid-producing foods and/or low in alkali-producing foods may contribute to the reduction in lean tissue mass. A study at the ARS nutrition center in Boston, Massachusetts, found that a diet high in fruits and vegetables, which are alkali-producing foods, favored preservation of muscle mass in older adults over a 3-year period.	Publication in peer-reviewed biomedical literature.	This information will be used by health professionals, consumers, and health researchers.	These results emphasize the importance of adequate fruits and vegetables in yet another aspect of health maintenance. It is anticipated these results will be used to modify dietary recommendations for older adults and by researchers in the field of diet and chronic disease prevention.
A publication describing a study in which females rats	Publication in peer-reviewed biomedical	The users are other researchers who will cite	Because the causes of obesity have been elusive,

<p>were overfed to induce obesity and the offspring were found to be “programmed” to also become obese without being overfed.</p>	<p>literature.</p>	<p>this work and build upon it.</p>	<p>great research effort is expended on the biology involved. One major theory based on observation of thousands of humans is that the intra-uterine environment sets the stage for adult obesity and this animal model affords a model to test this theory while controlling for all the variables that can modify the relationship in humans.</p>
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Measure 5.2.3 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

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

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

During FY 2010, ARS will

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

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

During FY 2011, ARS will

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

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

OBJECTIVE 5.3: IMPROVE NUTRITION ASSISTANCE PROGRAM MANAGEMENT AND CUSTOMER SERVICE

Activities related to this objective are primarily carried out by other USDA agencies.

Strategic Goal 6:

Protect and Enhance the Nation's Natural Resource Base and Environment

There is no substitute for fresh water, high quality soils, and clean air in productive agricultural ecosystems. Reliable supplies of food, fiber, feed, forages, and energy feedstock are essential for a productive agricultural sector and the maintenance of goods and services derived from the Nation's crop, pasture, and range lands. Agriculture relies on a healthy natural resource base whose sustainability depends on sound, science-based agricultural practices.

ARS research activities are designed to help ensure that the Nation's natural resources meet the long term needs of a vibrant society with its increasing population while enhancing the quality of life for producers, rural communities, and the Nation. To achieve these goals, ARS conducts multidisciplinary research to solve problems arising from the interaction between agriculture and the environment, and develops new practices and technologies to conserve the Nation's natural resource base and balance production efficiency with environmental quality. Since environmental quality is a global problem, ARS is expanding collaboration with international research institutions with the aim to produce technologies and practices that mitigate the adverse impacts of climate on agriculture and agriculture on the environment.

OBJECTIVE 6.1: ENHANCE WATERSHEDS' CAPACITIES TO DELIVER SAFE AND RELIABLE FRESH WATER

Water is fundamental to life and is a basic requirement for virtually all of our agricultural, industrial, urban, and recreational activities, as well as the sustained health of watersheds. ARS conducts fundamental and applied research on the processes that control water availability and quality for the health and economic growth of the American people. The Agency is working to develop and transfer to producers, action agencies, local communities, and resource advisors new knowledge, improved technologies, conservation practices, and decision support systems that will enable them to reuse degraded waters, improve water conservation, and increase water use efficiency in agriculture. This research will provide the tools to reduce the transport of agricultural pollutants and the associated degradation of terrestrial and aquatic ecosystems. The overall goal is to provide knowledge and tools to enhance water availability and quality, mitigate the adverse impact of droughts and floods on rural and urban communities, and improve the health of our Nation's watersheds.

Performance Measure

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.

Baseline 2005

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

Target 2011

Cumulatively, 10 agricultural practices and technologies will have been developed and used by customers to enhance water quality and availability.

Indicator 1:

During FY 2008, ARS will develop guidelines for irrigating in urban and agricultural settings with degraded waters.

FY 2008 Accomplishments:

1. Scientists released a new version of the HYDRUS-1D software package that includes new or improved capabilities for simulating: vapor flow; coupled water, vapor, and energy transport; dual-permeability type water flow and solute transport; evapotranspiration, transpiration, and precipitation; and biogeochemical reactions and transport.

Impact: This process-based model for contaminant transport is an important tool for predicting the fate and transport of agricultural contaminants in soils and groundwater. The model can be used to design optimal soil, water or crop management practices for using degraded waters. In addition, the new features make the software suitable for application to a broad range of agricultural and industrial subsurface pollution problems.

2. High salinity and selenium (Se) contents are major concerns for drainage water reuse in the Westside of San Joaquin Valley of California (SJV). Scientists identified plant species and poplar tree clones that were more adapted to sustainable drainage-water reuse strategies and for growing in areas with underlying poor quality waters in the Westside of the SJV.

Impact: Seed yields for oil crops ranged between 1 and 1.5 tons/acre, while poplar trees were annually cut and cuttings were considered for gasification uses. After 6 years, salt-tolerant plants lowered total soil Se via plant accumulation and volatilization; however, some leaching of newly deposited extractable Se also occurred. The findings improve options for sustainably using an agronomic-based system for drainage water reuse strategies, and encourage widespread usage in the problematic regions of central California

3. Water reuse can extend available fresh water supply and decrease drainage disposal requirements. Whereas many floral and ornamental crops are susceptible to salinity and specific ion toxicity and do not grow well using saline recycled waters, opportunities exist to use such degraded waters on tolerant species or during more tolerant growth stages.

Impact: Researchers produced premium stems of snapdragon with moderately saline waters and commercially acceptable stems of marigold with waters of low salinity. Three marigold cultivars maintained high aesthetic value and are appropriate for salt-affected landscapes. The research demonstrates that waste waters can be productively reused in green house floricultural practices, thus reducing the volume of waste water for disposal.

Indicator 2:

During FY 2008, ARS will develop guidelines for management practices that optimize soil, water, and economic benefits associated with drainage water management (DWM) systems in humid areas.

FY 2008 Accomplishments:

1. Scientists screened 55 industrial byproducts and found five that hold promise for removing nitrate, phosphate and atrazine from drainage waters when used in constructed bioreactors. Other researchers evaluated bioreactor filter designs and materials for phosphorus removal.

Impact: Bioreactor technology is an emergent component for improved water quality. Run off of nutrients from heavily fertilized or manured fields can be prevented with buffer strips but infiltration into buried drain lines can be a major source of water quality degradation. Nutrient contamination is a major water quality concern and can cause of hypoxia, and its remediation a national priority. Drainage water management can be improved by filtering drainage water, or the runoff in areas where diffuse flow is concentrated, through low cost materials such as industrial byproducts and agricultural waste products.

2. Researchers have denitrified drainage waters using immobilized sludge. In field tests, the immobilized sludge removed 50 percent of the nitrate-nitrogen from drainage water. The calculated removal rate was 94 g nitrate per day per square meter, which is dramatically higher than treatment wetlands of passive carbonaceous reactors.

Impact: Bioreactor technology is an emergent component for improved water quality. Run off of nutrients from heavily fertilized or manured fields can be prevented with buffer strips but infiltration into buried drain lines can be a major source of water quality degradation. Nutrient contamination is a major water quality concern and can cause of hypoxia, and its remediation a national priority. Drainage water management can be improved by filtering drainage water, or the runoff in areas where diffuse flow is concentrated, through low cost materials such as industrial byproducts and agricultural waste products.

Indicator 3:

During FY 2008, ARS will develop predictive equations, procedures, and databases that will allow improved estimation of concentrated flow erosion on agricultural fields and construction sites.

FY 2008 Accomplishments:

1. Scientists evaluated in-stream grade stabilization structures on the 2,132 ha Goodwin Creek Experimental Watershed in north Mississippi in an effort to quantify and predict the effects of enrolling erodible lands in the Conservation Reserve Program (CRP).

Impact: Measured rainfall, runoff, and sediment concentration data were applied to model simulations to demonstrate that the combined effect of grade control structures and change of crop lands to a CRP (reducing cultivated land from 26 to 8%) was to reduce sediment yields by 78% near the outlet of the watershed. This study provided a quantitative assessment of the effects of conservation practices to control erosion. The

information is needed by watershed managers seeking to reduce sediment loads and is useful to evaluate the performance of watershed simulation models.

2. Scientists completed a multi-year project with the goal to improve data access to promote analyses and interpretations of historic and current data on the Walnut Gulch Experimental Watershed. A special section of the Journal Water Resources Research and the associated Web site (<http://www.tucson.ars.ag.gov/dap/>) describe 50 years of data collection and the most recent research results.

Impact: These data will be invaluable for developing and testing rangeland erosion and sediment yield models and assessment tools. Short and long-term predictions of climate change effects are dependent upon models, which are dependent for validation on historic data sets.

3. Scientists have released an enhanced Bank-Stability and Toe-Erosion Model (BSTEM) that predicts sediment loadings from stream banks in a variety of environmental conditions by conducting simulations under existing and mitigated conditions. Using the model's improved root-reinforcement algorithms that account for species types, ages and distributions, riparian buffers that maximize bank stability can be designed and numerically tested.

Impact: Suspended sediment is one of the leading causes of surface water-quality impairment and recent studies have shown that stream banks are often the major sediment source in disturbed systems. The model was used to predict load reductions of 50-85% in different environments. BSTEM has been distributed to stakeholders in state and federal agencies and is taught in workshops at academic institutions and at national technical meetings.

4. Soil erosion from irrigated farm land has been reduced using sediment retention ponds, thus sustaining crop productivity. The Upper Snake-Rock (USR) Conservation Effects Assessment Project (CEAP) was initiated in 2005 to determine the long-term effectiveness of conservation practices in an irrigated watershed. Sediment retention ponds have been found to be an effective conservation method.

Impact: Suspended sediment loss decreased from 400 lb/acre in 1971 to 50 lb/acre in 2005. Sediment retention ponds installed in 2006 on one return flow stream reduced annual average sediment concentration from 400 mg/L in 2005 to 70 mg/L in 2007 and reduced sediment load by 5500 tons. Water flowing back to the Snake River from the 200,000 acre watershed is being monitored by ARS researchers in Kimberly, ID.

Measure 6.1.1 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS reported two agricultural practices and technologies developed and used by customers to enhance water quality and availability.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Information that goes into the National Information Drought Index System	An improved technique was developed to apply satellite sensor information	USDA, FAS, NRCS, NASA, European Space Agency, local and regional	Improved global monitoring of agricultural drought and improved crop yield

(NIDIS) is limited by the ability to measure and predict hydrological processes on the landscape. Sound estimates of infiltration and runoff components are needed to make accurate assessments of water availability between rainfall events.	to map drought and soil moisture at multiple scales to include data assimilation and validated models. Presentations of the technique have been made at national and international symposia, scientific publications.	water agencies, Operational hydrology and weather forecasting agencies.	forecasts. Enhanced accuracy of surface soil moisture retrieval products derived from current and planned satellite sensors. Enhanced possibilities for the effective mitigation of agricultural drought.
In order to quantify the effects of conservation practices on water quality, it is necessary to be able to relate measured changes in nutrients, sediment and pesticides to the extent of conservation implementation within the watershed. Assessment of installed practices is currently conducted through written and drive-by surveys. Satellite imagery can be used to remotely gather this information.	Algorithms for wetland mapping were developed remotely sensed radar data to provide dynamic maps of wetland cover. Algorithms were also developed for improved classification of agricultural land cover within crop rotational systems.	USDA NRCS, FAS, NASS federal and state environmental agencies, land managers and agricultural producers	Enhanced ability to remotely measure annual variations in land cover within agricultural landscapes and improved technologies for identifying wetland cover extent for water quality and ecosystems services applications.

Measure 6.1.1 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, ARS will

develop guidelines for irrigating in urban and agricultural settings with degraded waters.

develop guidelines for management practices that optimize soil, water, and economic benefits associated with drainage water management (DWM) systems in humid areas.

develop predictive equations, procedures, and databases that will allow improved estimation of concentrated flow erosion on agricultural fields and construction sites.

During FY 2010, ARS will

develop guidelines for water reuse in agricultural systems, including developing criteria for the application of waste water, developing water reuse best management practices, and utilizing waste water to mitigate drought..

develop guidelines for management practices that optimize soil, water, and economic benefits associated with drainage water management (DWM) systems in humid areas.

develop predictive equations, procedures, and databases that will allow improved estimation concentrated flow erosion on agricultural fields and construction sites.

During FY 2011, ARS will

develop guidelines for water reuse in agricultural systems, including developing criteria for the application of waste water, developing water reuse best management practices, and utilizing waste water to mitigate drought..

develop guidelines for management practices that optimize soil, water, and economic benefits associated with drainage water management (DWM) systems in humid areas.

develop predictive equations, procedures, and databases that will allow improved estimation of concentrated flow erosion on agricultural fields and construction sites.

OBJECTIVE 6.2: IMPROVE SOIL AND AIR QUALITY TO ENHANCE CROP PRODUCTION AND ENVIRONMENTAL QUALITY

High quality soil and air resources are essential for enhanced crop production and environmental stewardship. Productive soils enable efficient cycling of nutrients, help sequester atmospheric carbon, contribute to improved water and air quality, and foster other ecosystem services such as wildlife habitat. However, soils are vulnerable to degradation and damage through natural processes and human activities.

Air quality and atmospheric gas composition also have an impact on, and are in turn impacted by, agricultural production. Research is needed to control gaseous and particulate matter emissions from agricultural operations to protect air quality and mitigate impacts on climate.

ARS provides agricultural producers and land managers with strategies and technologies to enhance soil and air quality, and provides Federal and State agencies with science-based information to establish policy and regulatory decisions. For example, ARS research develops remedies for soil conditions limiting crop production and adversely affecting environmental quality. The Agency also works toward further developing safe and productive applications of animal manure and selected industrial and municipal byproducts as a low cost means of enhancing soil properties and improving crop production. Additionally, ARS is developing new measurement and prediction tools to determine the effects of agricultural land management practices on soil quality. In addressing its research objectives, ARS works to balance the stewardship of air and soil resources with the attainment of profitable and sustainable agricultural yields.

Performance Measure

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

Baseline 2005
Six agricultural practices and technologies to enhance soil and air natural resources developed and used by customers and partners.
Target 2011
Cumulatively, 18 agricultural practices and technologies to enhance soil and air natural resources will be developed and used by customers and partners.

Indicator 1:

During FY 2008, 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.

FY 2008 Accomplishments:

1. Weed invasions are considered one of the highest priority problems facing ranchers and rangeland managers, and new research suggests that weeds may enhance climate change as well. Soil emissions of two important greenhouse gases, carbon dioxide (CO₂) and nitrous oxide (N₂O), plus soil C and N were monitored in adjacent pastures dominated by Wyoming big sage (*Artemisia tridentata* ssp. *Wyomingensis*) with and without cheatgrass (*Bromus tectorum*) infestations. The results indicated that soil release of CO₂ and N₂O, plus C mineralization and nitrification all responded more strongly to simulated precipitation events in areas of cheatgrass infestation compared to non-invaded areas where native grasses like western wheatgrass (*Pascopyrum smithii*) were more abundant. In addition to their negative impacts on forage quality and biodiversity, weed invasions may contribute to the release of greenhouse gases by terrestrial ecosystems.

Impact: This information provides criteria for stratification of rangelands needed for management decisions seeking to balance productivity with greenhouse gas emission reductions. It will also be of use for estimates of terrestrial ecosystem greenhouse gas emissions.

2. Responding to Congressional mandate, the U.S. Climate Change Science Program commissioned an assessment [(Synthesis and Assessment Product (SAP) 4.3 with authors from ARS locations at Ames, IA; Maricopa, AZ; Urbana, IL; Ft. Collins, CO; Temple, TX; and Clay County, NE; and from several universities and other organizations] of the likely impacts on these fields over the next 30 years (corresponding to an increase in CO₂ concentration from 380 ppm to about 440 ppm and an increase in temperature of about 1.2°C). Among the many findings, the increasing CO₂ will likely increase crop yields from about 1% for corn to 9% for cotton, whereas the increase in temperature likely will cause decreases in yield except in more northern regions where increases likely will occur, so that net result of increasing CO₂ and temperature on yields likely will range from decreases of about 8% to increases of about 10%. At the same time, the elevated CO₂ likely will slightly decrease water use while the increased temperature will increase it slightly for little net effect on crop water use.

Impact: This report provides a key reference for climate change researchers, strategic decision makers, and the public on the impacts of climate change on agricultural productivity, land and water resources, and biodiversity. It will be used as decision-making criteria when planning research and setting policy dealing with climate change impacts, adaptation to changes of climate and mitigation of the impacts of natural and managed ecosystems on climate change.

3. One aspect of adapting agriculture to global change is identification of crop lines that can take better advantage of the rising concentration of carbon dioxide in the atmosphere. Work by ARS scientists in Beltsville, MD has shown that the yield of varieties of wheat and oats released about 100 years ago is much more stimulated by projected increases in carbon dioxide than is the yield of modern lines.

Impact: This work will aid crop breeders in developing varieties with high yield in future enhanced atmospheric carbon dioxide environments, thus enabling producers to take advantage of this aspect of changing climate.

4. Although global climate changes have been found to facilitate plant invasion, raising the possibility that agricultural ecosystems will be increasingly dominated by invasive plants, very

little is known about effects of altered precipitation. The effects of predicted increases in snow, summer precipitation, and nitrogen deposition, were tested on invasion of the North American mixed grass prairie, the largest remaining grassland on the continent. Although all three changes influenced invasion, increased snowfall had striking effects, greatly increasing the success of several invasive species.

Impact: These results add another aspect of climate change, altered snowfall, to the list of changes known to contribute to invasion. They also allow for more accurate predictions of both the types of invaders that will be most successful and the types of ecosystems that will be most susceptible to invasion under future climatic regimes. This information provides insights to the impacts of changing climate and is needed for effective management of agriculture's adaptation to the effects.

5. While most now accept that climate change is a reality, and many consider it the defining present-day environmental challenge, others wonder what it can possibly mean to them and what can be done to prepare for it. In a special feature edition of *Rangelands* and also in the U.S. Climate Change Program's Special Report, "The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity", we synthesized the current climate change literature and reported on the potential effects of climate change on American rangelands, and presented management options for the ranchers and land managers who will have to deal with this problem. Among the more important rangeland responses to climate change identified were changes in plant species composition, including weed invasions, reductions in forage quality, and in some regions, increased drought and animal stress. Adaptive management strategies for coping with climate change included increased rangeland monitoring, development and use of models for predicting rangeland responses to climate change, better weather forecasting, and changing management objectives.

Impact: The report provides management options for ranchers and land managers for adapting to the impacts of climate change that will enable sustained agricultural production and stewardship of natural resources.

Indicator 2:

During FY 2008, ARS will 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.

FY 2008 Accomplishments:

1. Management of soil carbon maintains soil quality and helps reduce CO₂ in the atmosphere that contributes to climate change. Organic cropping systems were assumed to result in less carbon sequestration than no-till systems, despite relatively large carbon inputs to soil via animal and green manures, due to the large amount of tillage required for organic systems. The net impact of low tillage and large carbon inputs on carbon sequestration compared to conventional practices, especially no till, were investigated. Results of research conducted at the long-term Beltsville Farming Systems Project by ARS researchers in Beltsville, MD include both organic and no till systems show that C sequestration is greater in three organic cropping systems than in two conventional systems. C sequestration in 2-, 3-, and 6-year organic crop rotations was greater than in a conventional till system by 10 to 19%, and was greater than in a no-till system by 3 to 11%.

Impact: The results offer insights to management practices that can be used to sequester C for soil quality improvements and to mitigate atmospheric greenhouse gas

concentrations. These data will be useful for C sequestration models, including models to be used by NRCS to establish conservation payments to farmers.

2. While chamber methods for measuring greenhouse gas fluxes from agricultural soils are widely used, it is well known that these methods are prone to potentially large errors resulting from the alteration of near-surface concentration gradients. In general, these errors result in an underestimation of the actual rate of gas transfer from soil to atmosphere. However, there is little information available for quantifying these errors. A numerical model was developed and theoretical analysis was performed which can be used together with soil physical property data to quantify method-specific chamber-based measurement errors. Application of these error analysis tools will result in more accurate estimates of emissions of greenhouse gases including carbon dioxide and nitrous oxide from agricultural soils.

Impact: The new method will result in improved national- and global-scale estimates of agricultural contributions to greenhouse gas emissions. It provides a tool for validating technologies adopted to reduce greenhouse gas emissions from agricultural sources.

3. Research was conducted by ARS researchers in AL to evaluate the contribution of agricultural management and rising atmospheric CO₂ to soil C sequestration and the ability of these systems to help mitigate the rise in atmospheric CO₂. Soil carbon was measured for 10 years in a cropping systems study comparing the effects of elevated atmospheric CO₂ in a conventional (standard tillage with no cover crops) vs. a conservation (no-till with three cover crops) management system. After four years, C was increased by elevated CO₂ and by conservation management in the top 5 cm of soil. Following an additional four years, significant increases were noted under the same treatments down to 10 cm of the soil profile. The results further demonstrate that conservation management can improve soil quality (via soil C sequestration) and that the improvements are enhanced under elevated atmospheric CO₂ conditions.

Impact: The results will be incorporated into management guidance for farmers seeking to incorporate carbon sequestration into production objectives as a contribution to reductions in the Nation's net greenhouse gas emissions.

4. During 2007, a study was initiated under irrigated, no-till continuous corn production to determine the effects of N source on N₂O emissions. Research from 2005 and 2006 suggested that applying a polymer-coated urea would reduce N₂O emissions from conservation tillage (CT) and NT corn fields. Multiple N sources, including polymer-coated fertilizers (encapsulated for slow-release control) were evaluated for greenhouse gas emissions. Fluxes of CO₂, CH₄ and N₂O were measured one to three times per week from May through October. Preliminary results (May through July, 2007) show reduced N₂O emissions from the polymer-coated N fertilizers. These preliminary results suggest that N₂O emissions can be reduced by selecting certain N fertilizer sources.

Impact: The results indicate that slow-release fertilizers can be used to reduce greenhouse gas emissions from cropping systems and enable agriculture to reduce its impact on climate. This provides an option for reducing the Nation's greenhouse gas emissions.

5. Agriculture contributes to greenhouse gas emission, which traps heat in the atmosphere. However, modification of agricultural management has the potential to shift agriculture from a net source of greenhouse gas to a net sink; thereby, agriculture could play a role in mitigating global climate change. Based on a literature synthesis current agricultural contributions to greenhouse gas emissions and C sequestration were summarized and strategies for how agriculture might lessen its burden on the greenhouse effect proposed.

Impact: This information will educate scientists, producers and the general public including policy-makers of strategies that allow agriculture to help mitigate greenhouse gas emission, and lessen the risk of further global climate change.

Indicator 3:

During FY 2008, ARS will develop practices which remediate degraded soils.

FY 2008 Accomplishments:

1. Integration of crops and livestock potentially offer economic benefits to producers by intensifying land use and improving resource efficiency. However, the impacts of this practice on soil organic matter are unknown. ARS scientists in GA conducted a 3-year field experiment with annual crops grown on land that was previously a perennial pasture. Two tillage systems were tested: moldboard plow initially to break sod followed by disking, and no tillage with herbicide application. Cropping systems included summer sorghum and corn with rye winter cover crop, and winter wheat with pearl millet summer cover crop. Cover crops were either grazed by cattle or left unharvested to mulch the soil. The type of tillage system was found to have the greatest influence on soil organic matter and microbial properties. If not tilled, the amount of soil organic matter remained very high near the soil surface and was equal to that of long-term pasture. When plowed, soil organic matter became uniformly distributed within the plow layer and the amount was eventually reduced due to greater decomposition. Cattle grazing on cover crops had no major negative influences on soil organic matter, and occasionally had positive influences on soil organic matter as cover crop biomass was cycled more rapidly to the soil through manure. The quality of soil, as evidenced by soil organic matter properties, was greater with no tillage than with conventional tillage. Therefore, crop and cattle producers who adopt integrated crop-livestock systems are encouraged to utilize conservation tillage management techniques to help retain soil organic matter and build soil quality.

Impact: This recommendation can be applicable to small- and medium-sized farms throughout the southeastern USA seeking to build soil quality. It contributes knowledge needed to improve and sustain soil resources needed for production of food, fiber, biofuels and ecosystem services.

2. Current corn and soybean management practices result in leaching of nitrate N and loss of P through erosion and overland flow. An assessment of soil quality indicators in the Iowa River South Fork Watershed showed the ratings for soil organic matter with the total organic carbon (TOC) and carbon to nitrogen (C:N) ratios being the lowest in upper landscape positions. This indicates erosion and nitrate leaching are more likely to occur in those areas, thus emphasizing the need for better conservation practices such as perennial or cover crops, no-tillage, and other management practices that can improve soil quality.

Impact: The results provide guidance for stratifying landscapes with corn and soybean cropping during efforts to remediate degraded soils. This contributes to the development of guidance for sustaining production on a variety of landscape positions.

3. In hilly landforms subject to long-term cultivation, erosion has removed topsoil from upper slope positions and accumulated topsoil in lower slope positions. Given the importance of soil erosion on productivity, an intuitive approach to reduce crop yield losses in eroded fields is to reverse soil erosion by moving soil from areas of soil accumulation back uphill. These experiments measured the effect of soil-landscape rehabilitation on soil properties and soil

productivity. Results indicate that addition of accumulated topsoil from lower slope positions to eroded upper slope positions can result in large yield increases in upper slope positions and more consistency in crop yields across the landscape.

Impact: Extension personnel, growers, crop consultants, regulatory agencies, and other scientists can use this information to better predict crop yield responses to soil properties and landscape position in eroded areas, to develop approaches to increase the productivity of eroded soils, and to recommend methods to remediate or restore eroded landscapes.

Indicator 4:

During FY 2008, ARS will develop methods to reduce emissions of harmful gases from crop and animal production systems.

FY 2008 Accomplishments:

1. A method to reduce local volatile organic compounds (VOC) emissions from soil fumigant applications is needed. VOC emissions are a precursor to the formation of ozone, an air pollutant that has harmful effects on human and environmental health, and the emissions constitute an economic loss for the producer when excessive emissions reduce fumigant effectiveness. A field experiment was conducted in the San Joaquin Valley by ARS scientists from the U.S. Salinity Laboratory, Riverside, CA to measure atmospheric emissions of a soil fumigant after typical injection into the soil of a vegetable grower's field. Irrigation of the soil surface shortly after the fumigant was injected into the soil, and periodically thereafter for several days, resulted in a 50% reduction of fumigant loss to the atmosphere when compared to emissions loss from non-irrigated field soil.

Impact: The results demonstrate a method to reduce regional VOC emissions, which will help the State of California meet EPA National Ambient Air Quality Standards for ozone, and will help growers of specialty crops minimize the loss of crop protection materials.

2. Pesticide volatilization is the least understood pathway by which pesticides are lost to the environment. As much as 25% of the surface-applied herbicide metolachlor can be lost through volatilization into the atmosphere, thus reducing weed control and potentially contaminating ecosystems adjacent to agricultural land. ARS scientists from Beltsville, MD and Ames, IA have been conducting intensively monitored, long-term pesticide volatilization studies to understand and measure soil characteristics and climatic variables governing field-scale pesticide volatilization. Results show that air temperature and surface soil water content interact so that moist soils can lose twice as much pesticide through volatilization as a dry soil. Soil surface and subsurface features like surface depression and subsurface restricting layers may influence soil water contents which in turn influence agrochemical behavior.

Impact: The results indicate that if soil water dynamics and meteorological variables for fields with surface applications of pesticides can be measured and modeled, management strategies to reduce pesticide losses to the atmosphere may be possible. Reduced loss of pesticides to the atmosphere will lead to better air quality and more efficient pesticide application with lower cost to producers.

3. High rates of manure may lead to nitrate leaching to ground water and fluxes of nitrogen oxides to the atmosphere, which may be reduced by nitrification inhibitors, such as nitrapyrin, that could reduce nitrate produced from the manure. This study tested the effect of nitrapyrin in manured soils under high moisture conditions and consisted of laboratory aerobic

incubations for 10 weeks. Five agricultural soils were studied with data collected on soil nitrate and ammonium N, microbial biomass N, denitrified N, and nitrous oxide fluxes. Nitrapyrin effectively reduced nitrification in manured soils, which could lower nitrate leaching by reducing the percentage of mineral N that is nitrate N. Nitrapyrin gave no consistent benefit for N₂O emissions, and did not increase net mineralizable N due to high denitrification N losses.

Impact: These results suggest that nitrification inhibitors would not improve the available soil N status in manured soils and would not reduce nitrous oxide emissions, thus eliminating the tested materials as potential solutions.

4. Natural filter media such as compost, soil, peat, and woodchips have been frequently used in biofiltration technology, but the natural filter media will decompose, settle, and compact with time. Powdered, activated carbon particles coated with polyvinyl alcohol gel (PVA) were characterized for adsorption capacity and evaluated in bench-scale experiments for reducing ammonia and hydrogen sulfide from swine manure aerated air. After an initial acclimation period, the PVA material removed 80% of ammonia and 97% of hydrogen sulfide; however, a significant increase in the greenhouse gas nitrous oxide was observed in the effluent gas. The PVA material served as an excellent medium for the attachment of microorganisms responsible for these major odorants.

Impact: PVA provides a solution to the removal of ammonia and hydrogen sulfide emissions from swine manure. Further work to optimize operational conditions is required to minimize nitrous oxide emissions.

Indicator 5:

During FY 2008, ARS will develop practices and approaches which mitigate the detrimental effects of tropospheric ozone on agricultural crops.

FY 2008 Accomplishments:

1. Although the effects of elevated CO₂ and ozone (O₃) on leaf expansion have been studied individually, few studies examine leaf expansion in more realistic simulations of future conditions, with simultaneously elevated CO₂ and O₃. This research examined leaf growth and expansion in soybean and aspen exposed to elevated CO₂ and elevated O₃ in a field setting to determine how growth parameters such as final leaf area, leaf number, and growth rate are altered by climate change. Leaves were larger upon unfolding in elevated CO₂ and smaller in elevated O₃, which compounded over time to alter final leaf area, even though relative growth rates were similar. Furthermore, carbohydrate concentrations were altered in old but not young leaves, indicating that changes in leaf size result from whole-plant, not leaf-level, responses. These results suggest that leaf growth is altered by CO₂ and O₃ very early on during growth, contrary to previous findings that only fully expanded, older leaves are sensitive to O₃.

Impact: This information provides guidance for detection and monitoring of ozone damage to crops. Further, it provides the information within the context of increasing atmospheric CO₂ that can be used for models needed to estimate ozone damage impacts on crop production.

2. Development of ozone tolerant plants is one approach to alleviate the adverse effects air pollution on agricultural crops. Progress toward improvement of ozone tolerance requires knowledge of the critical points in plant metabolism that can be manipulated to provide protection against ozone stress without sacrificing yield or other desirable characteristics.

Soybean genotypes exhibiting differential ozone sensitivity were compared to determine whether ozone tolerance was related to the concentration of ascorbic acid (vitamin C) in the fluid surrounding leaf cells, a cellular location where antioxidants have the potential to neutralize ozone before cellular injury can occur. Antioxidant compounds other than ascorbic acid were elevated in the extracellular fluid of the tolerant genotype. Identification of these compounds and their reactions with ozone is a critical topic for future research into the development of ozone tolerant crops.

Impact: The results are a step towards identification of specific compounds that once identified, can be a focus of breeding in the development of ozone-tolerant crops.

Indicator 6:

During FY 2008, ARS will develop management practices and decision tools to improve soil quality and protect the environment.

FY 2008 Accomplishments:

1. Inoculation with arbuscular mycorrhizal (AM) fungus produces on-farm increases strawberry yield. There are mounting concerns for the sustainability of current, chemically-based, agricultural practices. Small farm profitability, in particular, has been declining and would benefit from innovative, cost-effective means of increasing yields without additional agrochemical inputs. Arbuscular mycorrhizal (AM) fungi are beneficial soil fungi that colonize crop plant roots and help crops take up nutrients from the soil. ARS scientists from Wyndmoor, PA developed a method for on-farm production of AM fungus inoculum. Roots of young strawberry plants, inoculated with the AM fungi during the growth period prior to being transplanted in the field, had 17% greater yield than uninoculated plants. This translated into a \$4,720 per acre increase of income at a cost of \$28 for production of the inoculum.

Impact: Better utilization of the natural symbiosis between crops and AM fungi via the inoculum will require less chemical fertilizer applications for greater yields, and thus enhance the environmental and economic sustainability of U.S. agriculture.

2. Management practices designed to sequester carbon in soil require several years before sequestration is noticeable, and lack metrics to indicate if the practices are working during the interim. An indicator that can be used to judge the progress of efforts to increase soil carbon sequestration would provide a useful decision-making tool. A review of the peer-reviewed literature and data from on-going experiments on soil enzyme activity by ARS scientists at the National Soil Erosions Research Laboratory, West Lafayette, IN showed that β -glucosidase activity, when normalized to soil carbon content indicated the likely trend of soil carbon sequestration. This value ("BGN"), calculated as β -glucosidase activity divided by the soil carbon content, falls between 11 and 16 for sites with native vegetation, long-term pastures, and some no-till systems. High BGN values such as these indicate systems that will likely sequester carbon in the future. Low BGN values (< 11) indicate management systems that will result in degradation of the soil. The BGN value provides an early indicator of the impact of soil management systems on carbon sequestration and overall soil quality.

Impact: This new metric provides a means of determining whether changes to a management system are going to result in soil carbon stock changes without having to wait 3-5 years or longer before current analytical techniques can detect changes of soil carbon. Earlier determinations will enable earlier remedial management action when soil systems do not respond to management designed to sequester carbon.

Indicator 7:

During FY 2008, ARS will document the effectiveness of management practices and control technologies to reduce the emission of harmful gases from crop and animal production systems.

FY 2008 Accomplishments:

1. Ammonia loss from land application of dairy manure is a concern as the concentration of dairy cows in the southern Idaho has increased. Ammonia losses from three manure land application techniques (surface application and injection) were evaluated at six producers' farms in southern Idaho by scientists at the Northwest Irrigation and Soils Research Laboratory (NWISRL), Kimberly, ID, in collaboration with a local producer as part of a USDA NRCS Conservation Innovation Grant. Both surface application and injection produced the same ammonia losses, but injection of manure below the surface reduced ammonia losses by approximately 50%.

Impact: Utilizing a manure injection system for liquid dairy manures can retain more N for crop use and significantly decrease ammonia emissions, thus benefitting air quality.

2. Determination of soil carbon content plays an important role in the evaluation of global carbon sequestration, as well as soil quality and agricultural productivity. An on-farm experiment was conducted on five tilled fields on the Eastern Shore of Maryland, comparing four methods of collecting soil reflectance data: lab-based near infrared, lab-based mid-infrared, tractor-based transects of near-infrared and electrical conductivity; and airplane based near-infrared imagery. Results show that the mid-infrared produces the highest degree of accuracy in predicting soil carbon content and chemical concentrations. Airborne imagery performed as well as lab-based near-infrared sensors while covering a larger area.

Impact: Remote sensing imagery could play an important role in predicting the spatial distribution of soil carbon within the agricultural landscape, and thus provide a measurement and monitoring tool for soil carbon management. Soil carbon content determination across fields and landscapes has previously been based on point samples and interpolation between points, which suffers from significant error and uncertainty.

3. The state of California requires all pesticide products to provide testing to predict their potential to emit volatile organic compounds (VOCs) as a means to reduce air pollution, but the required test (thermogravimetric analysis (TGA)) provides no information on the nature of chemicals released during heating of the product sample. A group of sulfur fungicide products used widely in California exhibit a small mass loss during this TGA test, but this mass loss was found to be due to moisture rather than any VOC release.

Impact: This enhanced TGA testing approach will be used on other pesticide classes to more accurately assess their risk for atmospheric reactivity and contribution to ground level ozone formation.

Indicator 8:

During FY 2008, ARS will demonstrate the effectiveness of management practices and control technologies that will reduce nutrient losses, reduce emissions, and control pathogens from animal production operations.

FY 2008 Accomplishments:

1. Increasing ethanol production in North America has led to increased production of distillers dried grains with solubles (DDGS), the majority of which are fed to livestock. While there is

evidence that DDGS can be included into poultry diets at rates as high as 15%, there has been no data regarding the impacts of feeding DDGS at these rates on nutrient excretion and potential environmental impacts. The effects of broiler diets containing DDGS on nutrient excretion and nutrient solubility of manures was performed by an ARS scientist at the Northwest Irrigation and Soils Research Laboratory (NWISRL), Kimberly, ID, in collaboration with a scientist at the University of Saskatchewan, Saskatoon, Canada. As the inclusion of DDGS in poultry diets increased, nutrient digestibility decreased, both N and P output increased, and the solubility of excreted P increased.

Impact: When including high levels of DDGS in poultry diets because increasing N and P excretion can be an environmental concern. The results provide critically important information for formulating strategies to reduce nutrient losses from animal production operations.

2. An alternative treatment system was evaluated for odor control from swine production operations by ARS scientists in Florence, SC. The system included solid separation and nutrient removal processes. The evaluation included the analysis of six selected odor compounds that are known contributors to malodor in the liquid. Results showed that the concentrations of malodorous compounds were reduced by almost 99%. The majority of this odor reduction occurred during the biological N treatment step.

Impact: Two important advances were realized: 1) measurement of a suite of odor compounds in water provides quantitative and accurate assessment of odor reduction by treatment technologies; and 2) multi-stage treatment systems incorporating biological nitrogen removal can greatly reduce malodorous compounds in liquid swine manure.

3. To improve profitability, some small dairy farms in Pennsylvania are transitioning to greater use of managed pastures and organic production. Computer simulation of four Pennsylvania farms was used to evaluate the economic and environmental impacts of these practices. Grass-based systems using managed rotational grazing with animals maintained outdoors all year had lower erosion and phosphorus losses, lower production costs, and greater profit compared to systems using crop production, supplemental grazing, and winter confinement. The economic benefit of using organic practices was highly dependent upon the price difference between organic and conventional milk.

Impact: The simulations provide a decision-support tool for demonstrating various management strategies for reducing environmental impact while maintaining economically viable dairy farms. Potential economic and environmental benefits are encouraging producers on small dairy farms to consider grass-based and organic dairy production practices.

Indicator 9:

During FY 2008, ARS will deliver a Nitrogen Index (N Index) relative risk assessment tool that provides field guidance for potential movement of nitrogen via runoff, leachate, or gas emission from various landscapes and cropping systems.

FY 2008 Accomplishments:

1. Current fertilizer rate recommendations for the heavy clay soils of central Texas often do not result in meaningful crop yield improvements. ARS researchers from the Grassland Soil and Water Research Laboratory in Temple, TX developed new soil testing procedures for fertilizer recommendations. Fertilizer recommendations based on the new soil test methods were evaluated on local producer-owned farms and resulted in savings in fertilizer cost ranging from \$2,000 to \$40,000, depending on farm size, without a loss in crop yield.

Impact: Wide use of the new soil testing procedures will reduce fertilizer use, thus resulting in greater profits for farmers and decreased impact from excess fertilizer losses to the environment.

2. Continuous rice production in the Grand Prairie region of AR has suffered from a substantial (~19%) reduction of grain yield compared to rice rotated with soybean. Research attributed this yield loss to a deficiency of plant uptake of nitrogen during the middle of the growing season. This was due to decreased plant uptake of nitrogen derived from soil organic matter, while plant uptake of fertilizer nitrogen was less affected. ARS scientists in the Soil and Water Quality Research Laboratory in Ames, IA demonstrated that grain yield of continuous rice can be increased by adding more nitrogen fertilizer during the growing season as compensation for the decreased availability of soil organic nitrogen.

Impact: Improved understanding of organic nitrogen cycling in soils enables improved nitrogen fertilizer recommendations. This recommendation is being shared with and adopted by farmers and is expected to increase rice yields.

Indicator 10:

During FY 2008, ARS will develop instrumentation and models to measure and predict emission and dispersion of particulate matter and gases from animal production operations.

FY 2008 Accomplishments:

1. Estimation of particulate emissions is challenging, complex and highly uncertain. Variations in management practices may lead to unusual emission characteristics with substantial impact on downwind concentrations. A particulate emission study was conducted at a poultry facility in north-central Iowa. This study focused on the effect of buildings and a windbreak on the transport of particulates emitted from three large poultry buildings. Additional measurements on the emission of ammonia from these buildings were also made and found to be well correlated with the transport of particulates. A significant accomplishment was the determination that the flow field in the vicinity of buildings and windbreaks was significantly different than the traditional assumed Gaussian distribution.

Impact: The results will lead to better understanding and prediction of emission and dispersion of emissions from agricultural sources. The correlation of ammonia emissions with particulate emissions will enable prediction of transport both materials with a single measurement, thus making measurements more economical and enabling the use of a single set of factors to characterize the emission and dispersion processes of multiple materials.

2. Research towards incorporating ammonia volatilization into a whole-farm simulation model being developed by ARS researchers at University Park, PA (the Integrated Farm System Model or IFSM) was conducted. Ammonia volatilization from manure was found to be closely related to the pH at the manure surface, and this surface pH was found to be dependent upon the rate at which carbon dioxide was formed and emitted from the surface.

Impact: This is an important discovery that will be incorporated into process-based modeling of ammonia emissions from manure. The process model will be the basis for a decision support system that will help develop managements strategies to reduce ammonia emissions from agricultural sources.

3. Regional air quality in Idaho has become worse as the number of dairy cows has increased by approximately 80% in the last decade with concentrated dairy production facilities being the norm. Ammonia, methane, and nitrous oxide concentrations were measured on an open lot dairy using open-path Fourier transform infrared spectrometry (OP/FT-IR). This work was performed by ARS scientists at the Northwest Irrigation and Soils Research Laboratory (Nwisrl), Kimberly, ID, in collaboration with a scientist at the University of Idaho, Moscow, ID. This study reports some of the first ammonia, methane, and nitrous oxide concentration data from large scale open lot dairy production facilities utilizing an open path technique such as OP/FT-IR.

Impact: The study provides critically-need data for the development of emissions factors from open lot dairies. The emission factors will be used as the basis for policy decisions regarding agriculture and air quality, and provides a baseline data needed to develop emission control technologies.

Measure 6.2.1 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS reported two agricultural practices and technologies to enhance soil and air natural resources will be developed and used by customers and partners. ARS also reported four new technologies or strategies provided to manure and byproduct producers and users to improve profitability while meeting environmental objectives.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
Fertilizer recommendations based on the new soil test methods were evaluated on local producer-owned farms and resulted in savings in fertilizer cost ranging from \$2,000 to \$40,000, depending on farm size, without a loss in crop yield.	Fertilizer recommendations based on the new soil test methods were evaluated on local producer-owned farms and resulted in savings in fertilizer cost ranging from \$2,000 to \$40,000, depending on farm size, without a loss in crop yield.	Rice farmers.	Increased grain yield and more efficient use of nitrogen fertilizer.
Current satellites have coarse spatial resolutions, require considerable processing time, and may have problems with clouds. Unmanned Airborne Vehicles (UAV) overcome resolution, data delivery, and cloud cover issues and as a result may be important for acquiring data critical to sustainable farm management. ARS scientist in Beltsville, MD invented a sensor that can be flown on UAVs to provide important information at near-infrared wavelengths on crop and weed status of fields.	A patent application has been submitted.	Firms using unmanned airborne vehicle to gather information on crop and weed status of production fields, and producers using information from these systems.	The sensor provides timely information to farmers on crop nutrient status and weed populations to improve nutrient management and/or weed control. Reduced loss of excess agrochemicals to the environment and a reduction of production costs leading will result. The CRADA partner developed a new international company to use the camera as an image provider.
ARS scientists at Booneville, AR found that	A patent application entitled System for	Poultry producers who need economic and	: Applying poultry litter to pasture and bioenergy

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<p>imbedding poultry litter below the pasture surface can decrease these environmental problems by more than 90% while retaining the nutrients for plant productivity. The ARS research team developed a prototype machine, the ARS Poultry Litter Subsurfer, in cooperation with the National Soil Dynamics Laboratory, to make imbedding a practical management option for producers.</p>	<p>Distributing Poultry Litter below the Soil Surface was submitted for this technology by USDA-ARS in July 2008.</p>	<p>environmentally sound options for managing poultry litter and producers managing grasslands for grazing, hay and bioenergy feedstocks.</p>	<p>feedstock production sites offers an affordable alternative to expensive, energy-intensive commercial fertilizers. However, the current practice of spreading litter on the surface of pastures allows significant nutrient losses that decrease nutrient-use efficiency and often lead to serious odor and air- and water-quality problems. This technology will make it possible to lower the costs of crop production, meet water and air quality environmental standards, and make poultry litter a useful and profitable byproduct instead of waste product.</p>
<p>Use of condensed tannins to inhibit odor and emissions from stored swine manure.</p>	<p>Invention disclosure submitted.</p>	<p>Swine producers, extension agents, and other scientists.</p>	<p>Reduced production of odor and other emissions (greenhouse gases) from stored swine manure. Reduced odor and other emissions will lead to better air quality, reduced impact of agriculture on climate, and reduced nuisance complaints on odor from non-farm residents living near farms.</p>
<p>A bacterium has been isolated which, when fed to monogastric animals, has the ability to increase fiber digestion and decrease fecal output.</p>	<p>Invention disclosure.</p>	<p>Swine and poultry producers, feed industry, and scientists.</p>	<p>Based on the increased weight gain, blood glucose, and feed efficiency, the 10% increase in fiber digestion resulted in a 5% increase in energy to the animal, or a 5% increase in performance. Decreasing the fecal output by 20% would significantly reduce costs associated with manure applications; other cost savings could be incurred due to reduced costs from new facilities, decreased transportation costs, and elimination of extra storage units.</p>
<p>Subsoil injection of liquid dairy manure to reduce emissions.</p>	<p>Manure application field demonstration.</p>	<p>Idaho State Department of Agriculture and NRCS.</p>	<p>Improved air quality and more effective utilization of manure as a fertilizer sources from reduced loss of ammonia when land-applying dairy manure. The technology reduces ammonia loss by 50% over that of surface applications of dairy manure.</p>

Measure 6.2.1 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, 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.

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.

develop practices which remediate degraded soils.

develop methods to reduce emissions of harmful gases from crop and animal production systems.

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

develop management practices and decision tools to improve soil quality and protect the environment.

document the effectiveness of management practices and control technologies to reduce the emission of harmful gases from crop and animal production systems.

demonstrate the effectiveness of management practices and control technologies that will reduce nutrient losses, reduce emissions, and control pathogens from animal production operations.

deliver a nitrogen relative risk assessment tool that provides field guidance for potential movement of nitrogen via runoff, leachate, or gas emission from various landscapes and cropping systems.

develop instrumentation and models to measure and predict emission and dispersion of particulate matter and gases from animal production operations.

During FY 2010, 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.

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.

develop practices which remediate degraded soil, improve soil quality and protect the environment.

develop methods to reduce emissions of harmful gases and particulate matter from crop and animal production systems.

deliver a nitrogen relative risk assessment tool that provides field guidance for potential movement of nitrogen via runoff, leachate, or gas emission from various landscapes and cropping systems.

develop instrumentation and models to measure and predict emission and dispersion of particulate matter and gases from animal production operations.

During FY 2011, 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.

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.

develop practices which remediate degraded soil, improve soil quality and protect the environment.

develop methods to reduce emissions of harmful gases and particulate matter from crop and animal production and processing systems.

develop a nitrogen relative risk assessment tool that provides field guidance for potential movement of nitrogen via runoff, leachate, or gas emission from various landscapes and cropping systems.

develop instrumentation and models to measure and predict emission and dispersion of particulate matter and gases from agricultural operations.

OBJECTIVE 6.3: CONSERVE AND USE PASTURE AND RANGE LANDS EFFICIENTLY

Healthy, vigorous plant communities on diverse lands protect soil quality, prevent soil erosion, and provide sustainable forage and cover for livestock and wildlife. They also provide fiber and a diverse habitat for wildlife, improve water quality and sequester atmospheric carbon dioxide. The four serious threats that pose an increasing risk to the values, goods, and services provided by public and private pasture and range lands are wildfire, invasive species, loss of open space, and reduced profitability.

ARS works with public and private land stewards to maintain/enhance watersheds and landscapes and their environmental services. The Agency produces the scientific knowledge needed to actively manage pasture and range lands and maintain the health, diversity, and resilience of these ecosystems.

Key Outcomes: Pasture and range land management systems that enhance economic viability and environmental services.

Performance Measure

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

Baseline 2005
Fifteen new technologies or strategies provided to pasture, forage, and range land managers to conserve and restore natural resources while supporting profitable production.
Target 2011
Cumulatively, 39 new technologies or strategies will be provided to pasture, forage and range land managers to conserve and restore natural resources while supporting profitable production.

Indicator 1:

During FY 2008, 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.

FY 2008 Accomplishments:

1. Improved low-input grass licensed for southern pastures. Bahiagrass is a productive forage grass that requires low inputs and is well-suited for limited-resource and other livestock producers in the southern states. One problem with bahiagrass is that in newly seeded pastures, an establishment period of as much as 5-months is required before the grass can be grazed or cut for hay. ARS researchers at Tifton, GA have released TifQuik bahiagrass that has faster germination, fewer weeds during establishment, and can be cut for hay 4-5 weeks earlier than other varieties.

Impact: Three licenses have been granted for seed production and sales of the new variety and TifQuik was on the market for 2008 fall seeding. Access to this improved grass will increase profitability for producers by allowing reseeded land to be brought back into production more rapidly.

2. Forage legumes provide an important high-protein source for grazing livestock and wildlife. However, previously available forage legumes for use in the western U.S. were often lacking in persistence and the high cost of reseeding prevented their widespread use. ARS scientists at Logan, UT released 'DON' falcata alfalfa to provide the legume component in western pastures and rangelands to increase overall forage productivity and quality and to persist under harsh arid conditions.

Impact: This new release provides public and private land managers with a new option for adding a persistent legume component to benefit livestock and wildlife while increasing the fertility of the soil.

3. Vast areas of semiarid rangelands with sandy soils are severely disturbed, frequently burned, increasingly eroded, and invaded with cheatgrass and other weeds. In many cases, reseeding disturbed sandy rangelands with genetically improved plant materials that are competitive with weeds is the most effective and economically feasible option. ARS scientists at Logan, UT released Vavilov II, a more competitive Siberian wheatgrass, for lands with sandy soils and dominated by annual weeds. During the establishment year, Vavilov II had a significantly higher numbers of seedlings per unit area than earlier releases.

Impact: Vavilov II has already been distributed to six Department of Defense facilities. Estimates are that this grass will be a component in seed mixtures at over 40 military facilities encompassing over 1 million acres. Across the west, Vavilov II is expected to capture the Siberian wheatgrass market for use on harsh-dry sandy rangelands and help conserve soils and reduce the fire cycle.

4. New varieties of highly productive grasses are needed to keep livestock and bioenergy production viable in the Mid-West and Great Plains. ARS scientists at Lincoln, NE released three new cultivars ('Chief', 'Scout', and 'Warrior') of indiangrass, (*Sorghastrum nutans*), an important warm-season native grass for the region. These cultivars, each tailored to a different hardiness zone, improved cattle gains by producing significantly greater forage yields than other older indiangrass cultivars and often higher forage digestibility (IVDMD). In the regions where they are adapted, these cultivars also could be used in mixtures with other grasses in multi-species mixture to produce biomass for bioenergy.

Impact: The availability of improved indiangrasses offers producers new options for diversifying and improving their grasslands for forage-livestock and bioenergy systems. Diversifying grasslands will maintain high productivity for grazing and bioenergy production while reducing the risks of disease and improving wildlife habitat.

5. Intermediate wheatgrass is a widely used, high quality, high yielding perennial grass but its usefulness has been limited by a lack grazing persistence. ARS researchers at Mandan, ND bred and evaluated through grazing trials new and existing intermediate wheatgrass germplasms this work led to the development and released a new cultivar, 'Manifest' intermediate wheatgrass, with an exceptional yield and enhanced grazing persistence.

Impact: When sufficient seed quantities are available, Manifest is expected to have a significant economic impact by increasing yield up to 0.3 tons per acre on the 600,000 acres currently growing lower yielding, less persistent intermediate wheatgrasses.

Indicator 2:

During FY 2008, ARS will provide forage and pasture management technologies and strategies that reduce inputs while improving livestock performance and sustaining the environment.

FY 2008 Accomplishments:

1. Altering greenhouse gas emissions by modification of cattle diets on mixed-grass prairie. Use of dietary amendments such as condensed quebracho tannin to reduce nitrogen (N) in urine has been suggested as a possible strategy to decrease greenhouse gas (GHG)

emissions from livestock. ARS scientists at Mandan, ND compared the effects of tannin-affected cattle urine to normal cattle urine on carbon dioxide, methane, and nitrous oxide flux over a six-week period while the animals were on mixed grass prairie. Though the tannin urine treatment possessed 34% less N than normal cattle urine, overall nitrous oxide emission between the treatments did not differ, indicating that the nitrogen entered the environment through other pathways. Furthermore, methane uptake from the tannin urine treatment was 40% less than the normal urine treatment.

Impact: Results from this study suggest that the use of condensed quebracho tannin as a dietary amendment for livestock does not yield GHG mitigation benefits at least in the short-term. This knowledge will help producers save money by avoiding an ineffective procedure.

2. Locoweed's toxicity to cattle and other livestock has been well documented but less is known about how it affects horses. Swainsonine is the toxic substance in locoweed. ARS researchers at Logan, UT found that mares develop clinical signs of poisoning at doses of 0.25 mg swainsonine/kg of body weight/day for 14 days. This is a much lower rate than sheep and cattle, which require doses of 0.30 mg/kg for nearly 21 days before developing clinical signs.

Impact: Knowing that horses are highly susceptible to locoweed will alert horse owners, particularly those moving into locoweed-invested western states, to exercise care in where horses are pastured and aid veterinarians in diagnosing animal illnesses.

3. Poultry litter provides a rich source of nutrients for perennial forages and has the potential to be an affordable alternative to expensive, energy-intensive commercial fertilizers. However, the current practice of spreading litter on the surface of pastures allows significant nutrient losses that decrease nutrient-use efficiency and often lead to serious odor and air- and water-quality problems. ARS scientists at Booneville, AR found that embedding poultry litter below the pasture surface can decrease these environmental problems by more than 90% while retaining the nutrients for plant productivity. The ARS research team developed a prototype machine, the ARS Poultry Litter Subsurfer, in cooperation with the National Soil Dynamics Laboratory, to make imbedding a practical management option for producers. A patent application entitled System for Distributing Poultry Litter below the Soil Surface was submitted for this technology by USDA-ARS in July 2008.

Impact: This technology has the potential to improve pasture productivity and help solve both air-quality and water-quality problems on millions of acres of land associated with critical watersheds associated with municipal water supplies and wild and scenic rivers.

4. Growing switchgrass as a biofuel feedstock could enhance producers' income by increasing sequestration of carbon in the soil and the selling of carbon credits. The problem is the lack of data on how much carbon is actually sequestered. Nearly all measurements of soil organic carbon (SOC) change under switchgrass have been based on small plot research. While these assessments are useful, small plot research does not take into account spatial variability within or across farmer-managed fields. The fiscal and net energy economics of switchgrass grown as a biomass energy crop on ten farms in the central and northern Great Plains for a five year period has been reported. The soil carbon sequestration that occurred on the ten farms in these trials was determined in a cooperative study between ARS-Lincoln, NE and ARS-Mandan, ND by taking soil samples at the time the fields were planted and in the spring following the fifth year of production. Across these sites, SOC increased significantly demonstrating the potential of switchgrass as a carbon-sequestering bioenergy crop. The amount of sequestered soil carbon on the farms in this study exceeded the levels used in previous switchgrass life-cycle assessments (LCAs) for greenhouse gases. Change

in SOC across sites varied considerably, however, ranging from -0.6 to 4.3 Mg C ha⁻¹ yr⁻¹ for the 0-30 cm depth. Such variation in SOC change must be taken into consideration in LCAs of bioenergy crops such as switchgrass.

Impact: This information will aid in developing national policies on global climate change and help develop carbon trading markets that will open up additional sources of income for producers.

5. Particle size of forages fed to dairy cows impact feed intake, rumen health, milk fat content, and digestible energy available for milk production. However, little is known about how forage cell wall lignification interacts with plant tissue anatomy in large particles to impact forage fiber digestibility. To test whether internode length could predict degradation of stem tissues, ARS scientists at St. Paul, MN selected alfalfa genotypes for rate of fiber digestibility and examined them for internode length. The rapidly digested genotypes were found to have shorter internodes whereas those genotypes with slower fiber digestion had longer internodes.

Impact: These results suggest that plant breeders can select alfalfa plants that are more rapidly digestible by simply determining average length of stem internodes rather than using costly laboratory methods. This would result in significant savings of time and money in developing new varieties for livestock and some bioenergy production strategies.

Indicator 3:

During FY 2008, ARS will 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.

FY 2008 Accomplishments:

1. Considerable controversy exists over the impact of livestock grazing and prescribed fire in managing Great Basin rangelands to stop the spread of invasive cheatgrass and reduce wildfires. ARS scientists at Burns, OR evaluated the impacts of fire on sagebrush rangeland, which had either been grazed up until the year of burning (1993) or had been excluded from grazing since 1937. Vegetation characteristics were measured in the 12th through 14th years after burning. Burning caused a huge increase in cheatgrass (an invasive annual grass) in the ungrazed areas, but not in the grazed areas.

Impact: Grazing exclusion can increase the fire risk to sagebrush communities. This long-term research provides ranchers and public land managers with science-based information in selecting fire and grazing management practices for controlling cheatgrass.

2. Frequent ecological monitoring is essential to managing stream-side vegetation to maintain fish and wildlife habitat. Traditional ground monitoring of stream-related habitat is expensive because of manpower and travel costs. Very-large scale aerial (VLSA) surveys (low-altitude, high-resolution, intermittent aerial digital photography) were conducted successfully in a watershed inhabited by the Lahonton Cutthroat trout, a threatened species, to measure late-summer open water width, number and location of late-summer dry channels, widths of riparian areas and willow coverage, and riparian proper functioning condition. The VLSA technology completed the ecological assessment protocol imagery in an average of 4 staff hours per stream compared to 36 staff hours per stream for ground assessments.

Impact: Reduced labor requirements of VLSA more than compensate for its higher technology costs and demonstrate the potential for effective stream monitoring and ecological analyses at about half the costs.

3. Assessing impacts of global change on the grasslands of the western Great Plains is vital for long-term economic and environmental planning. ARS scientists at Cheyenne, WY as part of the Shortgrass Steppe Long Term Ecological Project (LTER) have studied the climatic attributes controlling net primary production, including spatial and temporal patterns in net primary production. The purpose was to assess how future global change may influence net primary production over the next 25 to 50 years. Yearly patterns of plant production were found to be determined largely by seasonal variations of temperature and precipitation with precipitation being the dominant factor on annual net primary production. Landscape effects such as grazing, soil nitrogen, and atmospheric CO₂ also affect temporal primary production but to a lesser degree. This information indicates that close monitoring of how global change affects precipitation patterns is a better indicator of shifts in plant productivity.

Impact: Land managers can focus their limited monitoring resources on changes in precipitation patterns to gather the most important information needed to make adjustments to stocking rates for livestock and wildlife based on changes in carrying capacity of the land in response to global change.

4. Millions of acres of western rangelands have been seriously degraded by invading cheatgrass. Cheatgrass crowds out plants essential to livestock and wildlife, while significantly increasing the frequency of wildfires. ARS scientists at Reno, NV studied how cheatgrass affects nutrient availability as it competes with other plants in desert shrub ecosystems. Ten years after invasion, they found that cheatgrass resulted in significantly greater plant biomass, significantly greater flux of carbon and a significant decrease in flux of calcium. The invaded plots also had significantly greater nitrogen availability deeper in the soil profile suggesting that cheatgrass invasion may increase the nitrogen leakiness of the system. This long-term research on how cheatgrass alters the soil is essential to developing science-based strategies for effective weed control strategies.

Impact: Knowing the impacts of cheatgrass on soil structure and function makes it clear that restoring native plant communities will first require rebuilding the soils before many native seeds can be successfully established. This knowledge will help land managers save money and restore ecological health by identifying restoration strategies with a reasonable chance of success.

5. Increasing costs for fuel, grains, and supplemental feeds are requiring livestock producers to consider new strategies to maintain profitability. ARS scientists at Las Cruces, NM have evaluated Criollo cattle that evolved in arid environments as an alternative to traditional breeds. They found Criollo cattle traveled farther to use a greater diversity of habitat types, and spent less time near water/riparian areas compared to British breeds. Criollo cattle also mature earlier with a greater probability of reaching puberty at a younger age.

Impact: These studies illustrate that in time of shifting markets, producers and researchers should evaluate heritage breeds such as the Criollo cattle to determine if they will be a more economically viable alternative for beef production systems in arid lands.

Measure 6.3.1 Summary of the Major Technologies Developed, Transferred, and Used in FY 2008:

During FY 2008, ARS reported four new technologies or strategies provided to managers of pasture, forage and range lands to improve conservation, restore natural resources, and increase profitability.

Describe the Technology	Describe the Transfer	Identify the Customer	Impact
ARS scientists at Logan, UT released Vavilov II, a more competitive Siberian wheatgrass, for use on semiarid lands with sandy soils that dominated by annual weeds. During the establishment year, Vavilov II had a significantly higher numbers of seedlings per unit area than earlier releases and is more competitive with the invasive weeds.	Joint ARS-Utah State University release with PVP (Plant Variety Protection) application. Six seed companies are now increasing seed to meet market demand.	Public and private land managers seeking effective and affordable improved plant materials for disturbed semi-arid sandy soils. Vavilov II has already been distributed to six Department of Defense facilities. Estimates are that this grass will be a component in seed mixtures at over 40 military facilities encompassing over 1 million acres.	Vast areas of semiarid rangelands with sandy soils are severely disturbed, frequently burned, increasingly eroded, and invaded with cheatgrass and other weeds. Across the west, Vavilov II is expected to capture the Siberian wheatgrass market for use on harsh-dry sandy rangelands and help conserve soils, provide forages for wildlife and livestock, and reduce the fire cycle by aiding in the control of invasive weeds.
Intermediate wheatgrass is a widely used, high quality, high yielding perennial grass but its usefulness has been limited by a lack grazing persistence. ARS researchers at Mandan, ND bred and evaluated through grazing trials new and existing intermediate wheatgrass germplasms this work led to the development and released a new cultivar, 'Manifest' intermediate wheatgrass, with an exceptional yield and enhanced grazing persistence.	Manifest has been jointly released by ARS and the NRCS Plant Material Center to the public.	Private and public land managers in the northern Great Plains seeking to improve productivity and soil and water conservation.	Manifest is expected to have a significant economic impact by increasing yield up to 0.3 tons per acre on the 600,000 acres currently growing lower yielding, less persistent intermediate wheatgrasses. Profitability will increase because of increase productivity and greater persistence will require less frequent re-seeding to maintain productivity.
ARS scientists at Lincoln, NE released three new cultivars ('Chief', 'Scout', and 'Warrior') of indiangrass, (<i>Sorghastrum nutans</i>), an important warm-season native grass for the region. These cultivars, each tailored to a different hardiness zone, improved cattle gains by producing significantly greater forage yields than other older indiangrass cultivars and often higher forage digestibility (IVDMD). In the regions	These varieties were jointly released to the public by the ARS and the University of Nebraska.	New varieties of highly productive grasses are needed to keep livestock and bioenergy production viable in the Mid-West and Great Plains.	The improved indiangrasses offer producers new options for increasing productivity for forage-livestock and bioenergy systems without increasing costs. Mixing the new grasses with other Diversifying grasslands will maintain high productivity for grazing and bioenergy production while reducing the risks of disease and improving wildlife habitat.

where they are adapted, these cultivars also could be used in mixtures with other grasses in multi-species mixture to produce biomass for bioenergy

Improved low-input grass licensed for southern pastures. ARS researchers at Tifton, GA develop TifQuik bahiagrass that has faster germination, fewer weeds during establishment, and can be cut for hay 4-5 weeks earlier than older bahiagrass varieties.

Three licenses have been granted for seed production and sales of the new variety and TifQuik was on the market for 2008 fall seeding. Access to this improved grass will increase profitability for producers by allowing reseeded land to be brought back into production more rapidly

Producers grazing livestock across the south from Georgia to Texas.

Bahiagrass is a productive forage grass that requires low inputs and is well-suited for limited-resource and other livestock producers in the southern states. One problem with bahiagrass has been that in newly seeded pastures, an establishment period of as much as 5-months is required before the grass can be grazed or cut for hay. TifQuik cuts the establishment period by 25% to pasture land can be returned to grazing sooner. This increases profitability significantly by reducing the amount of time hay and expensive supplements must be fed following reseeding.

Measure 6.3.1 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, 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.

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

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.

During FY 2010, 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.

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During FY 2011, 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.

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

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.

ARS Management Initiatives

ARS is continually assessing the relevance, quality, and performance of its research, providing agricultural information to the public through the National Agricultural Library and print and electronic media, ensuring adequate facilities to support Agency research, and ensuring a workplace conducive to personal and professional development.

MANAGEMENT INITIATIVE 1: ENSURING THE QUALITY, RELEVANCE, AND PERFORMANCE OF ARS RESEARCH (COVERS ALL RESEARCH OBJECTIVES)

The Office of Management and Budget (OMB) has established Governmentwide R&D Investment Criteria that are designed to assess the relevance, quality, and performance of Federally funded research, and ARS adopted the R&D Investment Criteria as a tool to measure its research. To establish the relevancy of the Agency's research programs, ARS relies on organized interactions with customers, stakeholders, and partners. Peer reviews conducted by the Office of Scientific Quality Review (OSQR) and the Research Position Evaluation System (RPES) ensure the quality of the Agency's research and scientific workforce. All research projects are assessed annually to determine the number of currently approved milestones that were met/not met during the preceding fiscal year. Near the end of the 5-year program cycle, National Programs are subject to retrospective reviews, which verify the scientific impact and programmatic relevance of the work conducted under each National Program Action Plan.

Performance Measure

MI 1.1 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.

Baseline 2004

As assessed against the Program Action Plans, the Agency's long-term goals, and the priority needs of U.S. agriculture, 97.1% of ARS' projects were conducting highly relevant research.

Target 2011

100% of ARS' projects will be conducting highly relevant research.

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

Baseline 2005

Using an average based on cumulative scores for the past five years, 76.1% of projects received scores of No, Minor, Moderate revision needed upon initial review and, overall, 97% received such scores by the completion of the review.

Target 2011

Using a cumulative five-year average, 80% of the projects reviewed will receive initial scores of No, Minor, or Moderate revision needed and 98% receive such scores by completion of review.

Baseline 2005

RPES conducted 392 scientific peer reviews of ARS scientists: 181 (46.2%) were upgraded, 203 (51.8%) remained in grade or were referred to the Super Grade Panel, 3 (0.8%) could not be graded because of insufficient information, and 5 (1.3%) had a grade/category problem.

Target 2011

RPES will conduct 400 scientific peer reviews of ARS scientists.

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

Baseline 2004

85.3% of ARS project milestones were fully or substantially met.

Target 2011

89% of ARS' project milestones will be fully or substantially met.

Baseline 2004

NPS completed three National Program Reviews.

Target 2011

NPS will complete National Program Reviews for all Programs in the first 5-year cycle and will begin reviews for the programs currently in the second 5-year cycle.

FY 2008 Accomplishments are reported under the USDA Performance Accountability Report and OMB PART requirements.

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

The [National Agricultural Library](#) (NAL) has statutory mandates to identify, collect, preserve in perpetuity, and provide access to quality information relevant to agriculture; serve as one of four national libraries; serve as USDA's library; provide leadership in developing and operating a comprehensive agricultural library and information network; and provide specialized information services through such NAL information centers and programs as the [Animal Welfare Information Center](#) (AWIC), the [Rural Information Center](#) (RIC), the [Food Safety Research Information Office](#), and the [Agriculture Network Information Center](#) (AgNIC). The library serves a large and broad customer base, including such audiences as policymakers, researchers, agricultural specialists, farmers, members of the library, educational and agribusiness sectors, food stamp recipients, and the general public. Recently, the library, with partners in the land-grant university and agricultural information service communities, has initiated development of the National Digital Library for Agriculture (NDLA).

Performance Measures

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

Baseline 2005

The National Agricultural Library total annual volume of customer service transactions exceeded 82 million.

Target 2011

The National Agricultural Library total annual volume of customer service transactions exceeds 145 million.

Indicator 1:

During FY 2008, NAL will continue to expand and improve services based on customer usage and satisfaction data.

In FY 2008, the National Agricultural Library (NAL) accomplished core mission objectives and planned for future service improvements in digital content and technologies. Fiscal challenges presented a rationale for NAL and ARS management to consider programmatic actions in FY 2009 and beyond needed to allow NAL to continue to fulfill its mandated mission. NAL issued a discussion paper - http://www.nal.usda.gov/about/reports/nal_report_web_041808.pdf - presenting options for satisfying recommendations of recent studies about NAL. NAL continues to explore and implement initiatives to improve and integrate operations and services through cost efficiencies and the application of digital technologies.

FY 2008 Accomplishments:

1. **High rankings by Web search engines.** In 2008, searches on the most popular Web search engines (Google, Yahoo, Ask.Com, and MSN) for information covered by 11 NAL information services (nutrition; invasive species; water quality, etc.) displayed the NAL service on the front page of results, often as the first result.

Impact: NAL continued to improve services to its broad and large customer base, with an emphasis on digital information products and services.

2. **Increased volume of direct customer services.** The Library's FY 2008 total volume of direct customer services increased to about 91 million transactions.

Impact: NAL continued to improve services to its broad and large customer base, with an emphasis on digital information products and services.

3. **Document Delivery.** The Library maintained a two-day turnaround time for all document delivery and interlibrary loan requests and the percentage of document delivery requests delivered digitally continued to increase. For the first time, more than one million articles were downloaded via NAL's DigiTop service, a 19 per cent increase over 2007 usage. NAL considered options for continuing to provide services based on the print collection at an affordable price. As requests decline the cost of providing the service becomes more costly. Several areas for further cost reductions were identified and will enable the services to be offered in FY 2009 while holding NAL's contribution to the FY 2008 level and maintaining the delivery fee at \$23/article.

Impact: Customers continue to receive rapid and reliable document delivery services from NAL at reasonable prices, with most delivered digitally to customer desktops.

4. **DigiTop, USDA's Digital Desktop Library.** In FY 2008, NAL continued to refine and expand content offered via its DigiTop service. Since the official launch of DigiTop in 2003, the total USDA investment in DigiTop content is about \$17 million and NAL's investment in computing infrastructure and staff in support has exceeded \$3.3 million. Usage of DigiTop resources continues to increase with FY 2008 article downloads approaching 1.1 million articles; up from 910,000 in FY 2007. The recurring cost of DigiTop content licenses has been borne by five USDA agencies and the Office of the Executive Secretariat. NAL will continue

discussions with non-participating USDA entities that purchase individually information resources to explore inclusion of these subscriptions in DigiTop and contain total service costs. NAL aims to maximize return on USDA investment and to leverage efficiencies of scale by bundling dispersed licenses into a single Department-wide agreement, negotiating better financial terms, widening product availability, and providing a unified access platform. These initiatives are designed to improve the effectiveness and reach of DigiTop for all aspects of Departmental activity. In FY 2009, NAL will continue efforts to refine and identify information content to support broad and specialized USDA interests. In addition, NAL will continue to explore collaboration on DigiTop service with other Federal agencies with missions related to USDA.

Impact: More online content was made available to USDA employees. Improved systems infrastructure increases reliability and saves customer time, by providing seamless delivery of documents from one integrated source rather than the previous two distinct systems.

- 5. AGRICOLA.** AGRICOLA is the catalog and index to NAL's printed and digital collections and a primary public source for world-wide access to agricultural information. AGRICOLA's value and relevance eroded over the last two decades due to funding challenges. NAL was unable to acquire all the content needed by customers for addition to the NAL collections (books, serials, technical reports, and documents related to agriculture). And, NAL was unable to support AGRICOLA operational production at a level sufficient to maintain a comprehensive and useful index of agricultural literature. Also, qualitative evaluation of AGRICOLA has documented serious gaps in continuous coverage due to indexing backlogs. **Currently, about 70,000 AGRICOLA index records are added annually by NAL staff and contractors.** This contrasts with the estimated annual publication output of almost 200,000 English language journal articles published on agriculture-related topics. In FY 2005 NAL initiated a process to redefine the scope of the AGRICOLA index to reflect realistic capacity and capabilities and to respond to NAL's mandate. NAL began indexing a new list of journals in 2007 and continued to index these journals in 2008. Rather than pursue a goal of comprehensiveness, the re-scoping of the AGRICOLA index focuses on publications authored by USDA scientists and digital and printed content material not included in indices offered by commercial indexing services. The re-scoped AGRICOLA index will continue to serve as the search tool to access NAL's collections and also serve as the access point for its digital repository AgSpace.

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

- 6. New Information Products and Services.** In response growing interest in bioenergy, NAL staff and others began developing a Web presence in FY 2007 on this topic and continues to assess the state of access to biofuels information. NAL has prepared a proposal to create a biofuels information center at the Library to coordinate federal information resources in this area and to facilitate research and discovery. NAL's Web blog, "InfoFarm" - <http://weblogs.nal.usda.gov/infofarm/> had its first anniversary in November 2008. It has stimulated conversation among NAL staff, with USDA partners, and the communities engaged in agriculture worldwide.

Impact: NAL continued to provide new products and services that respond to customer needs.

- 7. Web Portal Partnerships.** NAL continued its leadership and participation in Nutrition.gov (www.nutrition.gov), Science.gov (www.science.gov), and Invasivespeciesinfo.gov

(www.invasivespeciesinfo.gov), and its work with the National Library of Medicine and other partners on a Web portal for veterinary practitioners, and with national and international partners on WorldWideScience.org (www.worldwidescience.org). These partnerships are critical to the fulfillment of NAL's mandate to serve the nation.

Impact: NAL customers benefitted from increased access to NAL information products and services through partnerships which leveraged NAL and other institutions' information to provide broad and deep information at reduced cost.

8. Special Collections. A collection was acquired of USDA botanist and first director of the U.S. National Arboretum, Frederick Vernon Coville, relating to his work on blueberry breeding and development of the first hybrid blueberry. In celebration of the 300th anniversary of the birth of Carl Linnaeus, the father of taxonomy, a bibliography was updated listing over 300 items in the NAL collection. Sales products were produced from special collections images including some from a new publisher, Cavallini & Co.

Impact: NAL continued to highlight and preserve its rare and valuable materials.

9. Maryland AskUsnow virtual reference service. NAL joined the cooperative service of Maryland libraries, which, in collaboration with other libraries around the world, provide 24/7 online reference services to Maryland residents.

Impact: NAL continued to develop and deliver information products and services targeted to the information needs of its customers.

10. Facilities and Maintenance, Energy Conservation and Disaster Preparedness. NAL provides services from two facilities: the Abraham Lincoln Building located in Beltsville, Maryland and its Reference Center located in USDA's South Building. The Abraham Lincoln facility continues to experience serious operational challenges. NAL's identification as a mission critical facility underlines the need to address upgrades. In FY2008 NAL continued to make progress on projects to improve the Abraham Lincoln building using appropriated repair and maintenance funding. Work to develop plans for alternative facility options continued. NAL established an Energy Committee in late 2005 to involve colleagues in energy conservation because NAL was projecting a substantial increase in energy bills for FY2006. Due to the outstanding work of the committee and NAL employees, contractors, and collaborators, not only did NAL avoid the expected major extra costs, but actual cost reductions have also been achieved every year since. In FY2008, because of these economies, funds were available to replace obsolete IT equipment. NAL joined Safety Net – Federal Library Network for Disaster Response along with other federal libraries in the Washington area. Safety Net will be integrated into the Continuity of Operations Plan. NAL signed the Charter of Federal Library Mutual Disaster Assistance as one of the founding member libraries. NAL staff again presented refresher sessions for "Reacting to a Water Events" since the NAL facility continues to experience challenges due to leaking windows.

Impact: The NAL collections and people in the Abraham Lincoln building are better protected. Expenditures for electricity were reduced considerably. Improved disaster preparedness procedures and partnerships were put into place.

Measure MI 2.1 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, NAL will continue to expand and improve services based on customer usage and satisfaction data.

During FY 2010, NAL will continue to expand and improve services based on customer usage and satisfaction data.

During FY 2011, NAL will continue to expand and improve services based on customer usage and satisfaction data.

MI 2.2 The National Agricultural Library and partners implement the National Digital Library for Agriculture.**Baseline 2005**

The NAL and partners began formal discussions about developing the National Digital Library for Agriculture (NDLA).

Target 2011

The NDLA comprises more than 100 partner institutions that preserve and provide access to quality digital information, including millions of pages of digital content; is recognized widely, used extensively, and valued by the agricultural community; and is the U.S. agriculture component of the global digital science and technology knowledge base.

Indicator 1:

During FY 2008, NAL will continue to develop partnerships and content for the NDLA.

FY 2008 Accomplishments:

1. **AgNIC.** The 60+ Agriculture Network Information Center (AgNIC) Alliance - www.agnic.org – partner institutions implemented improved Web services; completed existing digital content-building projects and explored additional projects to enrich the array of digital resources available from AgNIC partner institutions and develop content for the National Digital Library for Agriculture (NDLA). In FY2008 AgNIC continued to: increase outreach by developing publications and presentations; develop further partnerships with international organizations; increase AgNIC membership and subject coverage; and work with the Leadership Council on Agricultural Information and Outreach to plan the development of future services and capabilities for the land-grant system and NAL. The AgNIC Alliance continues to improve information technology that supports the AgNIC portal (www.agnic.org). A major accomplishment during FY 2008 included implementation of automated retrieval of targeted digital repository resources about agricultural topics. This collection of over 30,000 records linking to full-text content provides an increasing supply of content for AgNIC users world-

wide. Staff concluded a pilot for the easy re-use of AgNIC partner resources using new technologies and clustered subject searching. NAL, in support of the AgNIC program and in pursuit in building full-text content for the National Digital Library for Agriculture (NDLA) awarded two new cooperative agreements in FY 2008 for a total of \$10,000. These cooperative agreements will help develop standards and model cooperative projects, infuse the NDLA with full-text, and create access to more digital full-text agricultural information via the AgNIC portal.

Impact: More important agriculture information has become available on the Web as a result of collaborations among NAL and AgNIC partners.

2. Partners in Public Health Partnership. NAL joined Partners in Information Access for the Public Health Workforce, <http://phpartners.org> which provides NAL opportunities to reach a much wider audience. One example of the new opportunities is an initiative to embed appropriate information about NAL services into public health curricula.

Impact: NAL's customers and partners continued to benefit from partnerships and collaborative activities.

3. AgSpace: the National Agricultural Library's Digital Repository. The publishing industry is undergoing a fundamental transition from print publications to digital content which is having a profound effect on science communications and the conduct of scientific research. To meet its core mission, NAL must continue to acquire, maintain, and preserve scholarly and scientific publications and other information content, in all formats, required to support agriculture. NAL and partner institutions began in the 1980s to explore systems and procedures to capture, store, and preserve digital information content for long-term access. In 2006 the Library began building a digital repository, AgSpace, which is connected to NAL's AGRICOLA database for search access. By the end of FY2009, 30,000 digital publications are expected to have been added to AgSpace. AgSpace contains digital copies of articles authored by ARS and other USDA researchers, digitized copies of USDA publications, and presentations and other unpublished works authored by USDA scientists. AgSpace will preserve the scientific work of USDA scientists and enable NAL to provide access to this information to USDA and the nation. AgSpace will also allow USDA to avoid incurring publisher-imposed author page charges needed for open access. AgSpace is viewed as a significant project in the research library community therefore a notice calling for public comment is scheduled for publication in the Federal Register in early 2009. We anticipate unveiling AgSpace to the public after the period for comments has concluded. In addition to the journal articles being captured for AgSpace NAL also makes available other full-text information digitized by NAL or NAL's institutional partners. By FY 2009, over 450,000 pages from such digitization projects were available, with over 17,000 documents hyper-linked to AGRICOLA for easy access. NAL has worked with Google to enable Google's search engine to crawl part of NAL's digitized collection, further exposing the content to customers worldwide.

Impact: Important publications have been digitized to preserve and provide access to them in perpetuity. NAL's capabilities to manage a new workflow involving digitization and digital preservation have been demonstrated by a sample digital repository.

Measure 2.2 Outyear Performance Plan (the future performance indicators for this Measure)

During FY 2009, NAL will continue to develop partnerships and content for the NDLA.

During FY 2010, NAL will continue to develop partnerships and content for the NDLA.

During FY 2011, NAL will continue to develop partnerships and content for the NDLA.

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.

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.

Baseline 2005

The FY 2005 Area Management Directive 715 (MD-715), Annual EEO Program Report was used as a management tool to identify potential barriers to creating and maintaining a diversified and qualified workplace, and to develop action plans to reduce/eliminate the barriers.

Target 2011

Reduce/eliminate barriers identified in the MD-715, Annual EEO Program Report.

Actionable Strategies/Activities for Management Initiative 3

- **Expand outreach activities in K-12 schools (long-term goal), universities/colleges, and minority serving institutions and organizations to educate students and faculty about scientific research and diversify the workforce.**

FY 2008 Accomplishments:

1. The Agricultural Research Service (ARS) continued to conduct outreach activities in K-12 schools, 1862 universities and colleges, 1890 land-grant universities, 1994 tribal colleges and universities, Historically Black Colleges, and Hispanic Serving Institutions. In addition, the agency continued to conduct outreach activities with minority serving organizations, such as the American Indian Science and Engineering Society (AISES), Minorities in Agriculture Natural Resources and Related Sciences (MANRRS), Society for Advancement of Chicanos/Latinos and Native Americans in Science (SACNAS), Society of American Indian Government Employees

(SAIGE) Conference, and the Workforce Recruitment Program (WRP). ARS staff participated in several of the planned events, including, but not limited to, resume critiques.

2. The Office of Outreach, Diversity, and Equal Opportunity (ODEO) is sustaining and enhancing linkages with **Tribal Colleges and Universities** focusing on established cooperative research and employment of American Indian students in agency laboratories by funding two (2) specific cooperative agreements between the University of Arizona and United Tribes Technical College (UTTC). The agreements were established during fiscal year (FY) 2005 to provide learning opportunities for students and faculty in agriculture and related disciplines. ARS participants learned about the impact Native American history, beliefs and cultural practices have on both how Native Americans view Western science and the scientific contributions they themselves have made. ARS participants were asked to step outside the familiar Western world view and examine the Native American tradition and experience from an Indian perspective, discussions centered around the definition of "Who is an Indian?," land issues, Indian cultural features and "How Indian People View Research." In addition, there were presentations on cultural differences between the dominant (White) culture and Indian cultures having to do with communication styles, work styles, kinship/family definitions, and how science and the natural worlds, and also about how Native Americans view research. In the Indian culture, research is valued for how it can be applied to benefit the community – "What question do we need to answer to make our situation better?" Scholarly knowledge is not itself sufficient reason to undertake a new study unless it will be reasonably led to improved conditions. It's not just the findings that have to be of benefit to the community, but also the process used to reach those findings. This collaboration is an opportunity to develop a strong partnership between USDA/ARS and tribal communities with mutual goals of expanding the minds of the next generation of employees and to encourage them to pursue careers with USDA/ARS. ARS continues to encourage Native American students to pursue disciplines related to agriculture and related sciences while providing educational and employment opportunities for future generations. ARS continued to support the specific cooperative agreements, which are administered by the Grand Forks Human Nutrition Research Center, within the ARS Northern Plains Area (NPA). During FY 2008, eight (8) Native American students received summer employment, which included salary, housing, and transportation, for eight (8) weeks. Four (4) of the eight (8) students were enrolled at the UTTC in Bismarck, North Dakota and four (4) students were enrolled at the University of Arizona. The students were assigned internships at (4) four locations in the NPA (Mandan, Fargo, and Grand Forks, North Dakota; and Brookings, South Dakota).
3. The funding for the Native American Internship Program has increased each year. During FY 2005, funding for both agreements totaled \$23,300. During FY 2008, the funding was approximately \$69,300. The NPA Office also sponsors a day-long cultural awareness workshop and a half-day showcase, which are held at the UTTC campus, and attended by NPA personnel and students, staff and faculty from UTTC.
4. The Office of ODEO continued to support four (4) USDA/**1890 National Scholars** by providing funding for tuition, fees, books, and the use of laptop computers. Having completed a Bachelor's Degree and a Dietetic Internship, one African American female student is currently enrolled in graduate school pursuing a Master's Degree in Nutrition with an expected graduation date of May 2008. The student is employed with ARS Delta Obesity Prevention Research Initiative (OPRI – formally the Delta Nutrition Intervention Research Initiative) as a Biological Science Trainee. The other scholars are African American females enrolled at Tuskegee, Langston, and South Carolina State Universities majoring in Accounting, Agricultural Business, and Civil Engineering, respectively. These mentored students are employed with ARS during the summer and will tentatively be converted to full time employees upon their graduation.
5. The OPRI has sustained a long standing partnership with several universities (University of Arkansas, Alcorn State University, and University of Southern Mississippi) to evaluate the

nutritional health in the Lower Mississippi Delta, to identify nutritionally responsible problems, and to design and evaluate interventions that may be sustained at the community level and implemented on a larger scale in similar areas of the United States.

6. Professional/Science-Based Organizations: Exhibits were set up and hosted at several scientific professional society events for the purpose of showcasing ARS careers and employment opportunities as well as to serve as a major advocate to specific communities and/or organizations, providing educational materials, enhancing not only ARS but also USDA at these events while improving the overall image of USDA with increased positive exposure in order to improve understanding of access to employment opportunities and understandings of ARS scientific mission:

- American Chemical Society Meeting and Expo
- American Indian Science and Engineering Society (AISES) Annual Conference
- Annual Biomedical Research Conference for Minority Students (ABRCMS)
- Entomological Society Meeting
- National FFA Organization (formerly known as Future Farmers of America until 1988)
- Hispanic Association of Colleges and Universities (HACU) Annual Conference
- Institute of Food Technologists Annual Meeting and Expo
- Minorities in Agriculture, Natural Resources and Related Sciences (MANRRS) Conference
- National Organization for the Professional Advancement of Black Chemists and Chemical Engineers (NOBCChE)
- National Technology Student Association
- Society for the Advancement of Chicanos and Native Americans in Science (SACNAS)
- Thurgood Marshall Leadership Institute

7. Other events: ARS staff participated in the following events with the same goals as indicated above:

- Alpha Zeta National Conference
- American Society of Microbiology, Minority Affairs Career Event
- Career Center Government Employee Panel, Texas A&M University
- Coshocton County Fall Foliage and Farm Fair
- Entomological Society of America, Pacific Branch Career Expo
- Grand Ronde Reservation Middle and High School Career Fair
- Hiring Heroes Job Fair
- Hispanic Leadership Program in Agriculture & Natural Resources Workshop, Texas A&M University
- Kansas Farm Bureau Annual Meeting
- Landowners Association of Texas 23rd Annual Farmers and Ranchers Conference
- Leadership Institute, UCLA Center for Community College Partnerships
- Leland High (Mississippi) School Career Day
- Maricopa High (Arizona) School Career Day
- Mid-America Farm Expo (Kansas)
- Military Job Fair, Frederick, Maryland
- Mississippi Institute on School, Health, Wellness, and Safety
- North Carolina PhD Career Fair
- Professional Agriculture Workers Conference
- Public Service Recognition Week, DC
- Sanderson High (North Carolina) School Hispanic Career Fair

- SouthEastern Pennsylvania Consortium for Higher Education (SEPCHE) Government Career Fair
- Texas Branch, American Society of Microbiology Spring Meeting
- Tift County High (Georgia) School Career/Job Fair
- Topeka Farm Show
- Umatilla-Morrow Education Service District Career Showcase
- University of Georgia, Capstone Class
- USDA Community Outreach Day at the Oaks Mission Indian School
- USDA Sponsored Job Fairs – Texas A&M University and Washington, DC
- USDA Agency Showcase and Regional Networking Event, California State University – Fresno, California
- Veterans of Military Service Career Expo
- Washington State Potato Conference
- Woodland High School Career Fair
- Youth Motivation Task Force (Alabama A&M University, University of Arkansas at Pine Bluff)
- 53rd Annual Mid-Columbia Regional Science and Engineering Fair

8. Colleges/Universities and K-12 Events: ARS staff participated in career fairs and career day events hosted by the following K-12 schools, colleges, and universities with the same goals as indicated above:

- Alcorn State University
- Anne Arundel Community College
- Arizona State University
- Boise Schools Career Fair
- Boise State University
- California State University – Fresno and Sacramento
- Central Arizona College
- College of Southern Idaho
- Colorado State University
- Columbia Basin College
- Concordia College, Moorhead, Minnesota – Marketplace for Kids (a yearly event sponsored by U.S. Senator Kent Conrad, North Dakota Agriculture Commissioner Roger Johnson, and North Dakota State Superintendent of Public Instruction Wayne Sanstead. The event encourages children to invent and market a product or an idea. Approximately 2,500 students participated).
- Cornell University
- Crowder College
- Delaware State University
- Delta State University
- Dillard University
- Fond du Lac Tribal and Community College
- Frostburg College
- Howard University
- Iowa State University
- Kansas State University
- Kids for Science – Prince George County, Maryland - The Beltsville Area Animal Improvement Programs Laboratory presented fourth-, fifth-, and sixth-grade awards (framed certificates with books) for the best project related to agriculture. Award nominees included 6 girls and 3 boys from African-American, Hispanic-American, Indian-American, and European American backgrounds.

- Lincoln University of Missouri
- Loyola University of New Orleans
- Miami Dade College
- Michigan State University
- Mississippi Valley State University
- Mountain State University
- North Carolina State University
- North Central Washington College
- North Dakota State University
- Northern Virginia Community College
- Oregon State University
- Pennsylvania State University
- Prairie View A&M University
- Purdue University
- Rochester Institute of Technology, National Technical Institute for the Deaf
- Sacramento State University
- Shepherd University
- Shippensburg University
- South Dakota State University
- Southeastern Louisiana University
- Southern University of New Orleans
- Tulane University
- University of Alaska-Anchorage and Fairbanks
- University of California – Davis and Riverside
- University of Central Florida
- University of Delaware
- University of Idaho
- University of Illinois – Champaign/Urbana
- University of Maryland, Baltimore County
- University of Minnesota
- University of Mississippi
- University of Missouri – Columbia
- University of Nebraska
- University of New Orleans
- University of Pennsylvania
- University of Portland
- Ursinus College
- Virginia State University
- Virginia Tech
- Washington State University
- Xavier University
- Yakima Valley Community College

9. Other Outreach Activities:

- Developed and posted 1-½ dozen new Sci4Kids stories targeted to kids 8-13 years old. These stories help kids learn about what ARS scientists do and how our science is wired into their everyday lives.
- Coordinated a 3-day all-school science enrichment program for a local elementary school serving a diverse population. The program, “Exploring Environmental Science,” reached

900 children. This is an ongoing program sponsored by Friends of Agricultural Research-Beltsville and Beltsville Agricultural Research Center (BARC) scientists. It features a new theme each year. The Program was awarded a President's Volunteer Service Award by the President's Council on Service and Civic participation.

- Partnered with the "Agriculture in the Classroom" Staff to expand awareness of ARS research at several education-oriented conferences such as the National Education Association (9,000 attending); American School Counselor Association Conference (2,000 attending); National Conference on Differentiated Instruction (5,500 attending); National Agriculture in the Classroom Conference (500 attending); and several summer agricultural institutes.
- Hosted 32 teacher/student programs at the National Visitor Center. Nearly 1,000 were reached, including both domestic and foreign students, underserved populations, and disabled students. Programs focused on a variety of topics, for example, biotechnology, energy and the environment, food science and nutrition, and dairy research.
- The Beltsville Area (BA), for the third consecutive year exhibited at the NBC-4 Health and Fitness Expo, which is held at the Washington Convention Center in Washington, DC. This event is very well attended and included a visit from Bill Cosby in 2008. The venue provides an outstanding opportunity for ARS to showcase our scientific achievements, the impacts of research on everyday food products and the phenomenal career opportunities that exist at the
- USDA. This year the BA invited the ARS Information Staff to participate as well. The event audience exceeded over 500,000 attendees from all demographic categories which makes it one of the most diverse events in the area. Our emphasis included education materials on phytonutrients, healthy food choices from the Food Pyramid, email newsletter enrollments, and career opportunities at the USDA specifically within ARS. Thousands of the participants were educated about ARS during the 2-day event.

10. Newly Established Partnerships:

- *Conference on Asian Pacific American Leadership (CAPAL)* – In 2008, ARS entered into a partnership with CAPAL to provide young Asian Pacific American leaders an opportunity to gain exposure to career opportunities with the Federal government in general and ARS in particular. The ARS Administrator and a CAPAL representative signed a Memorandum of Understanding, confirming that over the next five years, ARS will provide \$10,000 annually for the recruitment and placement of two research or management student interns at two ARS research locations. Each intern will be able to perform laboratory research in scientific fields of their interest on a part-time basis at ARS laboratories with the nation's leading researchers as a mentor while being fully enrolled in their academic degree programs, and may even be able to receive academic credit for the internship.
- *Beltsville Elementary School and Medix Technology School* – The BA has two Memorandums of Understanding (MOU) with the Beltsville Elementary School and Medix Technology School. The ARS BA employees are encouraged to volunteer as participants for tutoring science fairs, and in the Academic Mindcore endeavor which is an annual event at the Beltsville Elementary School. Students are given 100 questions and answers appropriate for their grade level in the areas of science, math, art, health, literature, music and social studies. Our employees serve to assist in testing the students to determine their ability to provide as many correct answers as possible.

The Medix MOU allows the BA scientists to serve as mentors to the students enrolled in the biological technician program which has an intern component for completion of the course. The scientists provides hands on learning experiences in the ARS research laboratories to further enable the students successfully acquire employment as trained laboratory assistants/technicians.

Update on current partnerships:

- Partnership with The Confederated Tribes of the Colville Reservation* – the ARS Root Disease and Biological Control Research Unit, Pacific West Area (PWA), Pullman, Washington, leads and coordinates a major science outreach program, *Pumping-Up the Math & Science Pipeline: Grade School to College* – Co-participants in the project include: all ARS Research Units at Pullman, Washington; USDA, Natural Resources Conservation Service; Washington State University Cooperative Extension and Department of Plant Pathology; South Puget Sound Community College; and Bellevue Community College. The program is intended to enhance and promote science, technology, engineering, and math (STEM) education and expertise among Native American and rural students from grade school through college. It also pairs high school and college students with ARS research mentors. The project has five components: (1) energy independence on the Colville Reservation by development of a science infrastructure and production of biofuels; (2) hands-on and face-to-face science education in Reservation and rural schools by world-class scientists; (3) organization of and participation in on-Reservation summer science camps; (4) administration of the ARS Pullman Location High School and College Summer Research Internship Program; and (5) promotion of employment opportunities for Native American students and students of color in ARS laboratories. Six (6) students have been hired on STEP (Student Temporary Experience Program) appointments as Bioscience Aids in ARS Research Units at Pullman, Washington and hundreds of students have been exposed to ARS research programs as part of the activities that the “Pipeline Program” sponsors. Recently, the “Pipeline Program” expanded its activities of STEM education and outreach to the Confederate Tribes of the Chehalis and to the Washington State University-College Assistance Migrant Program in order to reach more students and communities. One of the five components of the “Pumping-Up the Math and Science Pipeline: Grade School to College”, is the Skwant (translated ‘Waterfalls’) Life Science Camp at the Paschal Sherman Indian School on the Colville Reservation (established in 2007). The camp features ARS and university researchers presenting hands-on science modules in the classroom and the field to 70 students in grades 5-8.

The 2008 Administrator’s Outreach, Diversity, and Equal Opportunity Award in the Non-supervisory/Non-managerial category was awarded to two scientists from the Pullman, Washington location (one from the Root Disease and Biological Control Research Unit, Washington and the other from the Plant Germplasm, Introduction and Testing Research Unit) for their outstanding leadership and participation in outreach activities to Native American and Hispanic students.

- Penobscot Nation, Old Town, Maine* – for the past 12 years, the Research Leader of the ARS NAA New England Plant, Soil, and Water Laboratory, Orono, Maine, has worked with the Director of Education, Penobscot Nation and others to identify and successfully employed Native American Research Apprentices. The students selected work alongside Ph.D. scientists and technicians conducting research on biological controls of plant diseases and are exposed to the principles and practices of scientific research, as well as to USDA and ARS. The current student who was hired for the summer of 2008 was introduced (after learning of the student’s interest in hunting and fishing) to the Chair

of the Wildlife Ecology Department of the University of Maine and based on this introduction now has plans to pursue a bachelor's degree in wildlife ecology at the University of Maine. Twelve (12) Native American high school students have been successfully recruited in each of the last 12 summers (including 2008).

- *Tribal College Librarians Professional Development Institute* – in 2008, a staff member from the National Agricultural Library continued to work closely with the Institute and be active in the Tribal College and University Library Association. The staff member arranged for 515 books to be donated to nineteen of the Tribal College libraries. From 2005-2008 some 5,664 volumes have been provided for the library collections through his efforts. This staff member has also worked with American Indian Higher Education Consortium (AIHEC) officials and Tribal College library staff to develop strategies to provide electronic information resources to faculty and students at the colleges.
- *USDA Future Scientists – Student Outreach Initiative* – in conjunction with the Center for Mathematics and Science Education at Texas A&M University, ARS Southern Plains Area (SPA), College Station, TX continued supporting this cooperative agreement. The ARS PWA worked with the Director of the Future Scientists Educational Outreach Project to arrange for visits to five PWA locations (Pullman, Washington; Tucson, Arizona; and Riverside, Davis, and Shafter, California) to discuss the Future Scientist Project and the possibility of setting up mini institutes at three of the locations during the summer of 2009 and two in 2010. The Pullman and Riverside laboratories were selected because of their close proximity to USDA Hispanic Serving Institution Liaisons. The goal of the Future Scientists Initiative is to promote Agricultural Science in school districts in proximity to USDA-ARS research laboratories, focusing on hands-on, inquiry-based activities aligned with the National Science Education Standards. This collaboration takes the form of a mini-summer institute where 10 teachers spend two days at the selected research location interacting with scientists and technicians to learn about research specific to the laboratory and bring this experience back to their students. At the end of the year the teachers, a select number of students and their parents, would be invited back to the laboratory for a Student Research Presentation Day where students would present posters and talk about their research experience.
- *Bridge Internship and Job Preparation program (BIJP)* – In 2008, the Western Regional Research Center (WRRC), PWA announced a new Bridge Internship and Job Preparation (BIJP) program between WRRC and City College of San Francisco. This program was originally called the On-Ramp to Biotech program initiated by SFWorks, an affiliate of the San Francisco Chamber of Commerce. After nine cycles of internship placements in Bay Area laboratories, the On-Ramp program was transferred to City College of San Francisco and became the Bridge's Internship and Job Preparation (BIJP) program in August 2007.

The program entails a 180 hour laboratory assistant internship for working adults studying at City College of San Francisco and looking for a career change. The students have basic biotech skills (pipetting, making solutions, aseptic technique, bacterial culture, molarity, dilutions). The program is unique at WRRC in that the intern salaries are fully funded through a City College of San Francisco grant.

Currently, four WRRC Research Units are participating in the program with a total of twelve students. The diversity of the BIJP is evident in the enrollment: four Asian males and four Asian females; one Hispanic male; 1 White female; and two White males. Many of the supervisors who are participating in the BIJP also participated in the SFWorks program.

- *Society for the Advancement of Chicanos and Native Americans in Science (SACNAS)* – ARS has participated in the SACNAS annual conference for several years. The ARS representatives hosted an exhibit in FY 2008 to showcase the many career opportunities available within ARS and USDA.
- *American Indian Science and Engineering Society (AISES)* – for many years, ARS has participated in the annual conference of AISES by hosting exhibits to promote careers with ARS and USDA. Several ARS staff members have served on the Government Relations Council for AISES over the past years. The Associate Area Director for the ARS Mid South Area is an active participant in activities with AISES including chairing and serving as a poster competition judge, serving on the Government Relations Board, and implementing an extramural agreement grant annually for the AISES Graduate Student Poster competition. The Associate Area Director also served on the AISES Professional Awards for American Natives in STEM fields. The Associate Area Director has served on the committee from inception five years ago, which awards in science, engineering, and technical professionals as leaders for the future.

11. Additional Activities:

- ARS initiated a meeting with the University of Maryland, Baltimore County (UMBC), Meyerhoff Scholarship Program, in an effort to create a partnership between ARS and the Program. The Meyerhoff Program was created at UMBC in 1988 with a substantial grant from the Robert and Jane Meyerhoff Foundation. The initial grant enabled UMBC to launch a program of full support for outstanding African American students who would major in mathematics, science, engineering, or computer science and then pursue Ph.D.s in these areas. The Meyerhoff Program is open to all high achieving high school seniors who have an interest in pursuing doctoral study in the sciences or engineering, and who are interested in the advancement of minorities in the sciences and related fields. The Meyerhoff Program consists of top math and science students from across the nation. Students become part of the program community through an initial summer bridge experience, on campus residency, tutoring, faculty and staff involvement, cultural arts and outreach activities. As an outcome of this activity, during 2008, ARS staff:
 - Conducted an overview meeting with 20 students and 5 faculty members of the Meyerhoff Program at the BARC.
 - Participated in several on-campus career fairs.
 - Recruited and hired five current Meyerhoff Scholars for summer employment at the BARC for the summer 2008 (an investment of over \$20,000).
 - Coordinated a full-day event for incoming freshmen (69 students) to the Meyerhoff Scholars Program as part of their 8-week Summer Bridge Program.
- ARS contracted with a private local group in Corvallis, Oregon for the training of a disabled individual and planned for training of a group of disabled students that will occur later in 2009. Fifteen trainees (individuals with disabilities) are working at the ARS Corvallis location in the greenhouses.
- ARS worked with the State of Alaska Division of Vocational Rehabilitation to employ a high school student that is disabled. The student is currently working in a volunteer status for ARS and being paid by the State of Alaska.
- Recruited three Native American high school students from the Pyramid Lake Piute Tribe at the Exotic and Invasive Weeds Research Unit, Reno, Nevada. The Specific Cooperative Agreement (SCA) created in FY 2007 with the University of Nevada-Reno (UNR) included funding for summer student help. UNR will use these funds to employ three incoming 10th graders to assist ARS scientists in performing summer field work

under the SCA. The goal of this trial program is to expose children with an interest in science and natural resources to types of jobs that are available if they graduate from high school and college. All of these children are considered at risk for completing high school, let alone attending college.

- ARS hosted 13 students in the summer of FY 2008 with the American Chemical Society Project SEED Program [5 females and 8 males (10 Asian American/Pacific Islanders, 1 Black, and 2 Hispanics)].
- Continued efforts to support Historically Black Colleges and Universities (HBCUs), in keeping with the Department's initiatives, and in support of ARS efforts to strengthen the research and partnerships in the 1890 Land Grant Universities. ARS will continue utilizing the Capacity Building Grants program to improve the research and teaching capacity of the HBCUs, as it relates to agricultural and natural resource programs. This includes, but is not limited to, faculty and curriculum development programs and facilities improvement.
- Conducted two workshops, "How to Apply for Federal Jobs," for 100 participants attending the USDA Job Fair held in January 2008 and for 189 Hispanic Association of Colleges and Universities (HACU) Summer Interns in July 2008. At the request of HACU, another workshop will be conducted for the Fall 2009 Interns.
- Initiated a project with Southern University (SU), Baton Rouge, titled "Foreign Language in Agricultural Recruitment and Enhancement."(FLARE). The project goals are designed to use foreign languages and agricultural experiential learning to attract and train students for food and agricultural sciences careers. The project objectives are to recruit 10 undergraduate students from the existing pool of SU University College to enroll in one course in the College of Agricultural, Family and Consumer Sciences each semester, recruit 10 undergraduate students exclusively from the College of Agricultural, Family and Consumer Sciences to enroll in a Spanish course each semester, and recruit 10 undergraduate students to engage in an eight-week agricultural and foreign language summer institute each year. Summer program participants will gain research learning experience from existing SU Ag Center research projects. The summer program will culminate in a three-week Spanish language and cultural immersion for five top participants in El Salvador. Target students for each objective will be freshmen, sophomores and juniors. The project establishes a long term promotion of USDA among SU students.
- Participated in the 51st Annual Conference of the Southeastern Federal Recruiting Council (SEFRC). The SEFRC is a non-partisan organization that works to maintain effective working relationships between representatives from Federal agencies and educational institutions in the Southeastern Region of the United States. The theme for the conference, "Public Service: Our Students Are The Future" focused on the lessons learned, over the past 51 years, by both federal recruitment and career services professionals, while identifying viable initiatives to accomplish future goals in favor of public service. A presentation was made regarding the Federal hiring and application process. Networking opportunities during this conference were abundant with many colleges and universities throughout the Southeastern United States.
- Participated in a student forum at the Miami Dade College through the *Tools for Success* Program, a program funded through a five-year grant with the National Science Foundation for students working in STEM disciplines. Students participating in the *Tools for Success* Program (<http://www.toolsforsuccess.org/>) benefit from a full range of intensive and customized student services such as tutoring, advisement, mentoring,

transfer and career counseling, as well as specially designed enrichment activities such as podcasts, science forums, field trips, and other extra-curricular activities. Through this program, students have the opportunity to discover and experience the excitement of science, technology, engineering and math and learn about career opportunities. Tuition for each semester's special one-credit *Tools for Success* course, an annual service award of \$1,000 as well as an iPod are provided to students enrolled in the program. Approximately 70 students and faculty attended and participated in the lively discussion. Questions ranged from what types of opportunities are available for students to work in ARS and USDA to specific questions about the scientific research being conducted. Contacts made during this event are being nurtured with the hopes to hire some of these students in ARS programs throughout the United States as the students continue to pursue their degrees in STEM disciplines.

- Hired as an undergraduate Hispanic nutrition student who applied for and was accepted into a pilot summer research internship program at the BARC for 2008. The student joined two undergraduate and two graduate nutrition students from two HBCUs who were also selected to participate in the program. The program is designed to encourage minority student interest and experiences in nutrition research opportunities.
- Organized and developed a "Plant Biotechnology Workshop" which was held at the Barranquitas campus in Puerto Rico, May 2008. Three scientists from the ARS Beltsville Area, Floral and Nursery Plants Research Unit presented lectures to more than 20 teachers and students regarding plant biotechnology research areas and participated in demonstrations and hands-on experience in laboratory tools and protocols. This cooperative interaction will lead to teachers and students from Puerto Rico participating in research internships in the Floral and Nursery Plants Research Unit laboratories to be trained further in the areas of plant virology, plant transformation and development of plant molecular markers.
- The U.S. Arboretum staff and volunteers partnered with the Anacostia Watershed Society and the Humanities Council of Washington, DC's "Soul of the City" summer program to introduce 40 inner-city high school students to the concept of landscape through a walking tour of the collections and natural areas of the arboretum. The arboretum provides in-kind support for the Friends of the National Arboretum's Washington Youth Garden program, which provides hands-on gardening experience and healthy eating education for inner-city elementary aged school children.

- **Review and assess the utilization of the student programs [Student Temporary Employment Program (STEP), Student Career Experience Program (SCEP), and postdoctoral research associate programs]. Encourage managers to convert students who have previously participated in the program from the STEP to the SCEP.**

FY 2008 Accomplishments:

1. In 2008, ARS placed greater emphasis on the Student Temporary Employment Program (STEP), Student Career Experience Program (SCEP), and Postdoctoral Research Program. Managers received a number of messages encouraging them to convert students from the STEP to the SCEP. This initiative is one of ARS' goals to improve diversity in the workforce.

2. The ODEO Outreach and Recruitment Branch continued to track the participants in the ARS SCEP and the Post-Doctoral Research Associate Program as a recruitment initiative. Due to the high quantity of students hired, ARS has no mechanism to track STEPs. During 2008, ARS had 64 SCEPs (43.75% = minorities; 26.56% = White females; and 29.68% = White males. Twenty (20) SCEPs were converted in FY 2008 to permanent or temporary (i.e., temporary not to exceed a year or TERM appointments) positions. Of the 20 conversions, 35% = minorities; 30% = White females; and 35% = White males. During 2008, ARS had 294 Post-docs. Of the 294, 31.97% = minorities; 32.31% = White females; and 35.71% = White males. Nine (3.06%) have been converted to career conditional and TERM positions (22.22% = minorities; 11.11% = White females; and 66.66% = White males).
3. A group of six employees from the SPA Kika de la Garza Subtropical Agricultural Research Center received the Administrator's Outreach, Diversity, and Equal Opportunity Awards for the supervisory category in 2008 for successfully mentoring six Hispanic SCEPs (four males and two females). The group obtained and reviewed transcripts each semester to verify the SCEP employees about their grade point average; helped the SCEP employees study for their test and homework; developed Individual Development Plans and monitored their progress; and continuously emphasized to the SCEPs that their academic goal was their number one priority. SPA converted two of the SCEPs to permanent positions. The other four students are still employed at the Center and are continuing their program of study.

■ **Ensure that all employees complete mandatory USDA and recommended training.**

FY 2008 Accomplishments:

1. All ARS employees and contractors completed the mandatory training "Re-inventing Diversity for Today's USDA," utilizing AgLearn online training.
2. The ARS FY 2008 Civil Rights Training Plan included the EEO complaint process, reasonable accommodation process, NoFEAR Act, Sexual Harassment, Anti-Harassment, "What is the Difference Between Affirmative Action and Diversity?", Accountability Policy (mandated which Departmental Regulation 4300-010, Civil Rights Accountability Policy and Procedures, which holds all employees accountable to maintain an environment free of discrimination), and Management Directive 715.
3. Training included, but was not limited to educational videos and participating in small group discussions (such as brown bag lunches, etc.), taking part in interactive training class via the internet, reading pamphlets distributed by the Department/Agency. The above mentioned topics are also included in New Employee Orientation programs. The ODEO coordinated with the Human Resources Division (HRD) and the Area offices to ensure consistency in the new employee orientation packages/Research Leader/Supervisory training, and continued to encourage the Area ODEO Program Managers to be involved in the training sessions. ODEO's future training initiatives/strategies include enhanced visibility of ODEO and Area ODEO Program Managers to increase communication with all ARS employees and contractors.
4. Employees were encouraged to be part of the Special Emphasis Program (SEP) observances approved by the Office of Personnel Management to enhance their understanding and knowledge of each other's cultural differences and similarities and to learn about the uniqueness and talents that each employee brings to the ARS/USDA workplace. The Area ODEO Program Managers and/or SEP Managers were involved in the planning of nearly all of the Departmental SEP observances as well as sponsoring Area observances.

■ **Introduce Multigenerational Training and sponsor a Multigenerational Diversity Day.**

FY 2008 Accomplishments:

1. During FY 2008, the Deputy Administrator, Administrative and Financial Management, conducted Multigenerational Training at ARS Headquarters and in the Midwest Area.
2. The BA ODEO Program Manager formed a committee of summer hires that were named "Leaders of Tomorrow (LOT)," which was a diverse group of Biological Science Aids that work with the Scientists and Administrative Clerical Support to assist in the day to day operations in the office and laboratories. The establishment of this committee presents perspectives from all the generations currently employed in the Federal workforce.

■ **Determine if there is a need to create and maintain a formal pilot mentoring program to develop ARS' human capital to its fullest extent.**

FY 2008 Accomplishments:

1. ODEO continues to research the right vehicle to use to begin formal pilot mentoring program to ensure the development of employees in the competencies needed to accomplish current and future goals. In ARS, the HRD developed a mentoring program for new employees and several Area Offices have developed formal mentoring programs to mentor scientists. Mentoring of ARS students is occurring both in the Area and Headquarter offices. An Agency-wide pilot mentoring program is under development: Specific efforts are as follows:
 - The SPA Director continued the Mentoring Advisory Committee, which was established in 2007. The Committee consists of a diverse group of research leaders and scientists, and the Area ODEO Program Manager, to advise the Director of possible courses of action for improving/orienting Research Leaders, Laboratory Directors, and Center Directors toward mentoring scientists. They have developed the criteria, bylaws, etc., defined mentoring expectations, mentor/mentee roles, etc., for the program.
 - The PWA established a New Scientist Mentoring Program. The intent of this program is to augment the mentoring new scientists receive from their Research Leader (RL) and to assist them in their professional development and integration into ARS. This initiative grew out of a recommendation from the PWA Workforce Diversity Committee. It was felt that a lack of effective support systems had a negative impact on the retention of a diverse workforce. An examination of the workforce profile of the PWA indicated that higher graded positions, which are primarily scientist positions, are least reflective of the populations served in this geographic area. Therefore, it was decided to focus the initial mentoring efforts in PWA on Category 1 (research) and 4 (service) scientists.
 - The HRD established a mentoring program for new employees as a means of helping new employees assimilate into HRD and, ultimately, improve their rate of retaining employees.
 - The NPA continued to develop their Category 1 and 4 scientists in the "Newly Appointed Scientist Professional Development Program (NASPDP)". The goals of this program are

to assist the scientists in attaining standards of performance that will enhance their opportunity for success and to ensure fairness and equity in evaluating professional scientific development. The NASPDP provides a three-year period to enhance a newly appointed scientist's transition into an ARS scientific position and to carefully monitor and evaluate progress. This program covers all newly appointed Category 1 (research) and 4 (service) scientists, thereafter referred to as new scientists (including RLs) within the NPA. It includes all individuals hired under either merit or demonstration program authority and irrespective of their probationary status. Currently there are 34 mentors and 34 protégés (increased by four since FY 2007) in the program. Since the program's inception in 2005, there have been 17 protégés who have successfully completed the program.

■ **Maintain and increase involvement in knowledge management and mentoring activities to strengthen our workforce.**

FY 2008 Accomplishments:

- The Agency Administrator continued to stress to the Administrator's Council (ARS senior management team) the importance of encouraging employees to utilize career development and mentoring program.

The following strategies have been implemented to improve and enhance our efforts in succession planning and management:

1. Provided Situational Leadership II Training in ARS to promote partnering and increase collaboration between senior leaders, managers, supervisors and employees. Its use increases organizational awareness and performance, communication, and create an open environment for employees to express their career interest;
2. Leadership Development Training Programs to promote current employees to higher-level positions, i.e., the Aspiring Leader Program (GS-5-7 administrative assistants), New Leader Program (GS-7-11, administrative assistants, technician, and support scientists), Leadership Evaluation and Development Program (GS-11 and above administrative employees), Executive Leadership Program for Mid-level employees (GS-11-13 scientists, managers, team leaders, and project leaders), ARS Path to Leadership Program (GS-12 and above scientists, managers, team leaders, and project leaders), Executive Potential Program (GS-13-15 scientists, managers, and supervisors), and the Executive Professional Excellence and Knowledge (GS-14 and above) are promoted and announced agency-wide in the Research, Education, and Economic mission area to offer opportunities for one to strengthen leadership, professional development and growth and career advancement;
3. Provide career development training as needed to assist employees on how to establish action plans towards career planning and career paths;
4. Establish and oversee the mentoring program, career enhancement program and career intern programs to support those employees in developing and demonstrating the use of core and leadership competencies to work more efficient and effective in their assigned role;
5. Provided New Research Leader (RL) Training to RLs to help them in the transition and management of their administrative role, function and responsibilities;
6. Send annual reminders to managers and supervisors for Individual Development Plans to be established to support and help employees develop career path and plans;

7. Undergo internal audits for accountability and management of various programs, i.e., Human Resource Management Evaluations and Consolidated Assistance, Review, and Evaluation reviews; and ,
8. Administered a survey to RLs (April 2008), compiled and shared the responses with the Administrative Council in June 2008 to develop strategies and action plan to attract, hire, and retain quality scientists. One of the results of the RL's survey was the establishment of a Research Leader Advisory Council (RLAC). The charter instituting the RLAC was signed by the ARS Administrator on October 29, 2008. By December 31, 2009, the RLAC plans to determine what is needed to develop strategies and action plan to attract, hire, and retain quality scientists.

The BA established a MOU with the Medix Technology School. The Medix MOU allows the BA scientists to serve as mentors to the students enrolled in the biological technician program which has an intern component for completion of the course. The scientists provides hands on learning experiences in the ARS research laboratories to further enable the students successfully acquire employment as trained laboratory assistants/technicians.

- **Create, implement, and maintain a secure and confidential electronic exit interview process to determine why employees choose to leave ARS. Develop a plan to overcome any obstacles in the workforce.**

FY 2008 Accomplishments:

1. The HRD submitted a draft "Exit Interview" to the Civil Rights Staffs within the Research, Education and Economics mission area for review. Requested revisions were made with two outstanding items to be addressed. One item requires final agreement on the content/wording of a small number of the revised questions. The second pending item concerns addressing additional steps that need to be taken to ensure that participants feel their responses are anonymous. HRD provided additional information on the process of survey distribution in Survey Monkey (survey tool) which will hopefully alleviate the concern. HRD also submitted a request to the ARS Office of the Chief Information Officer that an entry website be created to allow control to be given to field representatives (Area ODEO Program Managers) for the release of the survey invitation to separating employees. Tentative implementation of the exit interview survey is the end of the 2009 calendar year.
2. As part of the Management Directive 715 (MD-715) process, a barrier analyses and elimination planning process was conducted to identify problems and barriers to create a model EEO workforce. The MD-715 report and plans to eliminate the identified barriers were developed through close collaboration and input from the Area ODEO Program Managers, Special Emphasis Program Managers, HRD, and the ODEO staff (EEO and Compliance Branch and the Outreach and Recruitment Branch) by first conducting self-assessment checklists to identify any barriers in ARS policies and procedures, followed by a workforce analysis to ensure equal employment for all groups. Other management tools used to determine obstacles in the workforce include the Federal Equal Opportunity Recruitment Plan (FEORP) and the Disabled Veterans Affirmative Action Plan.

- **Encourage employees to utilize the ARS programs such as career development, mentoring, and Special Emphasis Programs, and to serve on EEO/Diversity Advisory Committees.**

FY 2008 Accomplishments:

1. *Career Development and mentoring* - The Agency Administrator and Deputy Administrator, Administrative and Financial Management (AFM), continued to stress to the Administrator's Council the importance of encouraging employees to utilize career development and mentoring programs, such as the Aspiring Leader Program (GS-5-7 administrative assistants), New Leader Program (GS-7-11, administrative assistants, technician, and support scientists), Leadership Evaluation and Development Program (GS-11 and above administrative employees), Executive Leadership Program for Mid-level employees (GS-11-13 scientists, managers, team leaders, and project leaders), Executive Potential Program (GS-13-15 scientists, managers, and supervisors), and the Executive Professional Excellence and Knowledge (GS-14 and above). The following display the race, national origin, and gender of the participants, which shows a slight increase in diversity since 2007 with the exception of the Executive Potential Program:
 - Aspiring Leader Program (ALP - GS 5-7) – 3 Black and 1 White female.
 - New Leader Program (NLP - GS 7-11) – 3 Black females, 1 Black male, 1 Hispanic female, and 6 White females.
 - Executive Leadership Program (ELP - GS 11-13) – 1 Black male; 1 Black female, 2 White females, and 1 White male.
 - Leadership Evaluation and Development (LEAD) Program – 5 White females, 1 Asian, male, and 2 White males.
 - Executive Potential Program (EPP) – 7 White males.
 - New Research Leader Training Program (NRLTP) – 3 Asian males, 4 White females, and 15 White males.
 - Senior Executive Service Candidate Development Program (SESCDP) – 1 Hispanic female, 1 Black female, 1 Black male, and 6 White males.

2. *Special Emphasis Programs and EEO/Diversity Advisory Committees* - Each ARS Area has established Area EEO/Diversity Advisory Committees, which serve as management tools and advisors to ensure that the targeted groups are appropriately represented throughout the workforce. The EEO/Diversity Advisory Committees sponsored special activities designed to enhance diversity awareness. Special Emphasis Program (SEP) observances approved by the Office of Personnel Management or supported by the USDA Office of Civil Rights were sponsored by the Area EEO/Diversity Committees and available to all ARS employees. The ARS SEP Manager was involved in the planning of nearly all of the Departmental SEP observances. Employees are encouraged to participate in SEP observances, which are designed to raise awareness and educate employees on the cultural differences, similarities, and historical contributions.
 - The BARC's Diversity Committee was revitalized and the mission of the committee includes determining what barriers may exist that will prevent BARC from becoming a workplace that attracts diverse candidates; determining what initiatives and programs can be implemented that will encourage students from diverse backgrounds to engage in modern agricultural science which automatically incorporates advanced math and science courses into their curriculum; and encouraging students from diverse backgrounds to pursue education in science through speaking opportunities, personal interaction, technical development and mentoring experiences.

- The AFM Employee Advisory Committee observed a number of special emphasis observances, including but not limited to, National Disability Employment Awareness Month, Martin Luther King Jr.'s Birthday, Black History Month, and Women's History Month.
3. Career development, leadership, and mentoring programs are as follows:
- The Office of Outreach, Diversity, and Equal Opportunity (ODEO) Outreach and Recruitment Branch conducted Knowledge, Skills, and Ability (KSA)/Resume Writing workshops for over 100 participants at the January 2008 USDA Job Fair and for 189 Hispanic Association of Colleges and Universities interns on KSA/Resume Writing and Navigating the Federal Hiring Process in July 2008. This was useful in teaching participants to understand how to apply for federal jobs and the importance of accuracy and responding to the KSAs.
 - The PWA established a New Scientist Mentoring Program. The intent of this program is to augment the mentoring new scientists receive from their Research Leader and to assist them in their professional development and integration into ARS. This initiative grew out of a recommendation from the PWA Workforce Diversity Committee. It was felt that a lack of effective support systems had a negative impact on the retention of a diverse workforce. An examination of the workforce file of the PWA indicated that higher graded positions, which are primarily scientist positions, are least reflective of the populations served in this geographic area. Therefore, it was decided to focus the initial mentoring efforts in PWA on Category 1 (research) and 4 (service) scientists.
 - The NPA continued to develop their Category 1 and 4 scientists in the "Newly Appointed Scientist Professional Development Program (NASPDP)". The goals of this program are to assist the scientists in attaining standards of performance that will enhance their opportunity for success and to ensure fairness and equity in evaluation professional scientific development. The NASPDP provides a three-year period to enhance a newly appointed scientist's transition into an ARS scientific position and to carefully monitor and evaluate their progress. This program covers all newly appointed Category 1 and 4 scientists, thereafter referred to as new scientists within the NPA. It includes all individuals hired under either merit or demonstration program authority and irrespective of their probationary status. Currently there are 34 mentors and 34 protégés in the program. Since the program's inception in 2005, there have been 17 protégés who have successfully completed the program.
- **Promote consistency in new employee, Research Leader, and scientist orientation programs throughout ARS regarding all components of the EEO Program.**

FY 2008 Accomplishments:

1. The ODEO coordinated with the HRD and Area ODEO Program Managers to ensure consistency in the New Employee, New Research Leader, and Scientist Orientation programs regarding all components of the EEO Program. The following items were included in the various trainings: ODEO Vision/Mission statement, current FY USDA/ARS/Area (if applicable) EEO/CR Policy Statements; ARS Sexual Harassment Policy Statement; Anti-Harassment Policy Statement; Reasonable Accommodation Brochure; EEO Complaint Process; DR-4300-010, Civil Rights

Accountability Policy and Procedures; and EEO Mediation/Alternative Dispute Resolution information.

2. During FY 2008, the ODEO Director, and/or his representative, and the ODEO Area Program Managers participated in each of the New Employee, New Research Leader, and New Scientist Orientation programs

- **Identify barriers to parity among minorities and women in Agency award recognition programs; increase award recognition parity among minorities and women.**

FY 2008 Accomplishments:

1. The ARS HRD is in the process of collecting data to analyze the distribution of awards among Scientists, Biological Science Technicians, and administrative support positions for FY 2008. The data is projected to be available for analysis in March 2009. Once an analysis of the report data is completed, an action plan will be implemented to identify and develop strategies and remedies to modify and improve current processes.

- **Ensure that civil rights personnel are more visible to all employees, i.e., Area Civil Rights Managers, EEO/Diversity Committees, Civil Rights Staff participating in the CARE (Consolidated Assistance, Review, and Evaluation) Program and the Human Capital Management Assessments.**

FY 2008 Accomplishments:

1. The Director, ODEO, visited each Area Office and met with employees to explain how ODEO can assist in matters pertaining to ODEO issues and conducted a question and answer segment. Other ODEO staff members continue to serve ARS employees with technical support and guidance.
2. ODEO continued to maintain visibility throughout the Agency by participating in the varied programs and activities listed herein. ODEO continued to encourage the Area ODEO Program Managers to visit Location offices to assist with outreach, diversity, and equal opportunity.
3. There will be an ODEO representative for each of the six teams for the FY 2009 Consolidated Assistance, Review, and Evaluation (CARE) program reviews, whereas in FY 2008, there were only two ODEO representatives.

MANAGEMENT INITIATIVE 4: DEVELOP OUTREACH ACTIVITIES THAT WILL ENABLE ARS TO BETTER SUPPORT THE USDA INITIATIVE TO INCREASE SERVICES TO LIMITED RESOURCE, SOCIALLY DISADVANTAGED, AND/OR HISTORICALLY UNDERSERVED FARMERS AND RANCHERS.

USDA has identified a number of issues related to how it serves or fails to serve that segment of the U.S. agricultural community that has been historically underserved by many Government programs. These studies did not identify specific issues or problems in the USDA research programs, but in 2000, ARS decided to take a more active approach to see how the knowledge and technologies developed through its intramural research activities could be made available to Outreach target populations (historically underserved, limited resource, and/or socially disadvantaged).

Performance Measures

MI 4.1 Bring the benefits of ARS research to underserved populations and organizations serving these target populations by providing them with access to ARS-generated knowledge and technology that enables them to increase their productivity and profitability.

Baseline 2005

ARS has an Agency Outreach Coordinator and an Outreach Coordinator in every Area. The Agency Outreach Coordinator will answer directly to the Associate Administrator of NPS. The Outreach Coordinators are responsible for actively seeking ways to reduce/eliminate internal barriers that prevent target populations from accessing ARS research products.

Target 2011

Area Outreach Coordinators will identify organizations and individuals that serve the underserved populations who are potential users of ARS research and work to reduce/eliminate barriers to their participation.

MI 4.2 Identify significant Outreach activities and report them annually to the USDA Office of Outreach.

Baseline 2005

ARS identified 20 significant Outreach activities and reported them to the Departmental Office of Outreach as requested.

Target 2011

ARS will cumulatively report 100 significant Outreach Activities to the USDA Office of Outreach and through the GPRA Annual Performance Report.

Actionable Strategies/Activities for Management Initiative 4

- Provide leadership to forge interagency efforts to better serve underserved populations (partnerships within USDA, and with other Federal agencies, State agencies, universities, and private organizations)
- Increase extramural agreements with organizations that serve underserved populations.
- Increase the number of invitations extended to representatives of underserved populations to participate in program workshops, symposia, project/program reviews, and site/location reviews.
- Increase the number of research collaborations and technology transfer activities focused on meeting the special needs of this target population.
- Identify good examples of recent research that can or will be useful to target populations and ways to help them access this information.
- Ensure that appropriate employees are aware of the outreach initiative and their responsibilities in it.
- Promote knowledge of the outreach initiative to new employees, as appropriate.

ARS Administrative and Financial Management (AFM) Initiatives

OVERVIEW OF AFM INITIATIVES

ARS' Administrative and Financial Management (AFM) initiatives link with USDA's management initiatives to support more efficient program operations and deliver scientific excellence and public service.

AFM expects to:

- Ensure an efficient, high performing, high quality, diverse workforce to fully accomplish the ARS mission and work cooperatively with partners and the private sector.
- Ensure ARS sustains a clean annual audit opinion and provides access to quality financial information through financial systems that meet the needs of their users.
- Enhance ARS effectiveness through effective and automated services for acquisition, personal property, and administrative management.
- Link budget decisions and program priorities more closely with program performance and consider the full cost of programs.
- Reduce improper payments by establishing targets and corrective actions.
- Efficiently and effectively manage real property through good stewardship (*i.e.*, acquisition, maintenance, and disposal) of ARS' real property assets.
- Award extramural agreements in an efficient and timely manner, and ensure they are legally and fiscally sound and in full compliance with established policies and procedures.
- Ensure systems fully meet needs for AFM information and guidance in support of the President's Management Agenda and E-Gov initiatives.

FY 2008 Accomplishments:

- The Human Resources Division performed a pilot project within ARS to develop a Peer Panel Review process for classifying high level (*i.e.*, GS-14 and GS-15) Service Scientist (Category 4) positions based on the existing Research Scientist (Category 1) classification system, the Research Position Evaluation System (RPES). The pilot project utilized two panels of scientific peers to review the possible accretion of duties promotions for high-level Service Scientists, who may have impacted the classification of their position based on their expertise and scientific contributions. The pilot was initiated to enhance the application of the appropriate scientific position classification standard(s). Panelist, employee, and management feedback were gathered and a recommendation for expanded use of the Category 4 Peer Panel Review process is being drafted.

- The Human Resources Division issued three Policies and Procedures updates (Policies and Procedures 402.3, Premium Pay; 402.4, Administrative Leave and Excused Absence; and, 431.3 Research Position and Evaluation System), one Manual update (Manual 431.3, Research Position Evaluation System), and one brand new Policies and Procedures (Policies and Procedures 402.1, Flexible Work Schedule Program). The continuous release and update of human resources related issuances ensure that related functions and activities are performed in a consistent and up-to-date manner consistent with prevailing management objectives and existing legal and regulatory guidance.
- ARS developed two new performance plan requirements regarding supervisory and leadership development for all supervisory positions in the agency that improve accountability and monitoring for critical human capital management supervisory responsibilities. One of the requirements was a standard performance element and standard for “Supervision and Human Capital Management.” The “Supervision and Human Capital Management” performance element highlights the importance of successful supervision and leadership and promotes a consistent view of the inherent responsibilities and expectations for all ARS supervisors. The second requirement was to evaluate supervisors’ performance in providing quality services and products to meet customer and stakeholder needs. The inclusion of standard language into supervisory performance plans that emphasize the concept of the integral nature of customer/stakeholder perspective to the performance/deliverance of quality products and services supports the ARS’ Management Initiative of “Ensuring the Quality, Relevance, and Performance of ARS Research (Covers All Research Objectives).”
- ARS continues to meet Departmental and Treasury accounting and reporting challenges including prompt resolution of any adverse accounting conditions, accurate reconciliation of Congressional Appropriation and Treasury Cash balances and, timely response and closeout of pertinent Audit findings. To this end, ARS has sustained a clean audit opinion of our Annual Audited Financial Statements and has met all accelerated Department close out dates.
- ARS continues to promote and provide web based access to all Financial and Travel documents, policies, and procedures. At every opportunity, our web sites are updated with timely and pertinent travel and financial policy. ARS recently completed an extensive policy manual on all facets of reimbursable accounting, billing, and closeout practices and has published extensive guidance on domestic and foreign travel policy. All such information is accessible on-line to customers and stakeholders.
- The Acquisition and Property Division (APD) implemented U.S. Bank’s electronic reconciliation system that replaced the Purchase Card Management System (PCMS). Access Online will be used to establish and manage the purchase card program and purchase card accounts, including card/check issuance and account approval. Purchase card transaction data will be immediately available for users of the system. Web-based training is available for users on the bank’s system and Departmental purchase card policy.
- APD continued to represent the REE Mission Area Agencies at Departmental meetings to develop the strategies for implementing the new Personal Property module in the Corporate Property Automated Information System (CPAIS) including training. The system is still targeted for implementation in FY 2009.
- The Design Manual P&P 242.1 and P&P 134.2 Energy, Water and Sustainability Policy and A-E contracts to comply with EPACT 2005, EO 13423 and EISA were revised. Over 25% of ARS

facilities received energy audits in FY 2008. UESCs and ESPCs are being utilized to identify and implement energy conservation measures. Headquarters, Area, and location facilities energy managers have been designated. Advanced electric meters are being installed at major facilities. Alternative utility procurement sources are being utilized to reduce costs. Electricity, natural gas, steam, fuel oil, and vehicle surveys have been conducted to determine how energy is being used in the Agency in order to conserve it. An energy awareness program has been implemented.

- Successfully implemented mandatory annual training for all ARS Authorized Departmental Officer's Designated Representatives (ADODRs). The training material provided ADODRs with the fundamental knowledge of responsibilities required to effectively monitor extramural agreements. Delivery of the annual training to ARS administrative personnel serving as Authorized Departmental Officers (ADOs), ensured effective and efficient administration and close out of extramural agreements. The following extramural agreement bulletins were developed, updated, and/or published in 2008:

[08-703 Standard Cooperative Agreement](#)

[08-702 Authorized Departmental Officers Designated Representative Training Requirements](#)

[08-700 Agricultural Research Information System/Agreements Information Management System Data Entry Requirements for the Research Support Agreement](#)

- ARS has supported the Department and President's e-government initiatives and recently implemented the e-government travel solution, GovTrip. GovTrip offers all ARS employees a web based, on-line travel arrangement, monitoring, reporting, and payment process with options for direct pay of Government Travel Card charges also employed Agency-wide by ARS. All ARS travelers benefit from electronic access of travel information, as well as the benefits of a Travel Card process to reduce and eliminate the need for cash.
- The Human Resources Division utilized two e-HR systems to streamline and enhance personnel suitability background investigation processing and tracking. The Electronic Questionnaires for Investigations Process (e-QIP) system was expanded for use in processing National Agency Checks with Written Inquiries (NACIs) and a web-based Security Entry Tracking System (webSETS) was implemented to monitor and track NACI and higher level background investigations.

The use of e-QIP for submission of background investigation forms was expanded to include employees requiring NACIs REE wide. E-QIP allows REE employees to log on from anywhere to electronically enter, update, and transmit their personal investigative data over a secure Internet connection to the Personnel Security Staff for review and approval, greatly simplifying and securing the process of submitting NACI paperwork to OPM for investigation.

WebSETS was implemented to replace the existing in-house developed personnel security tracking systems (which included a separate tracking system for NACIs and for higher level background investigations). WebSETS allows for new reporting functions not previously available in the in-house personnel security tracking system and for consistent sharing of data with the Department. These enhancements ensure that ARS/REE remain in compliance with Department

and OPM initiatives related to Personnel Security. In addition, the enhancements better position ARS/REE to address new personnel security requirements such as those resulting from Homeland Security Presidential Directive 12 (HSPD-12).

- The Human Resources Division deployed a web-based Time and Attendance system (webTA) for paperless submission and approval of employee time and attendance records and leave requests for ARS and CSREES. WebTA interfaces directly with the National Finance Center (NFC) to ensure accurate, secure and timely salary processing and leave balance calculation. In addition, webTA maintains a history of all records previously certified and submitted through webTA. These records are available to the employee, timekeeper and/or supervisor as long as the employee is an active employee, providing an accurate and reliable source of official time and attendance records and will help to ensure that REE time and attendance procedures continue to meet the standards of a variety of federally-mandated compliance requirements. HRD is continuing to work with the relevant stakeholders to improve webTA functionality to meet NASS needs.

AFM Goal 1: Improved Human Capital Management

Objective: Research, Education, and Economics Agencies have a highly qualified diverse workforce to fully accomplish the REE mission.

Performance Measure 1.1 Hire people with agency-desired skill sets.

Indicators:

By FY 2011, AFM will:

*Identify current and future skills gaps within each REE agency
Actively recruit to ensure maximum opportunity for all
Develop a sound marketing strategy to attract top candidates
Develop metrics to guide improvement in the hiring process*

Performance Measure 1.2 Emphasize employee continuous improvement.

Indicators:

By FY 2011, AFM will:

*Develop a career development template to assist employees to grow in the agency.
Develop and implement an employee continuous education requirement.
Retain and share corporate knowledge by defining/developing and implementing Knowledge Management.*

Performance Measure 1.3 REE Agencies retain/achieve top ranking in USDA as “Best Places to Work” as reported in the Federal Human Capital Survey.

Indicators:

By FY 2011, AFM will:

*Develop a program/process to assimilate and support new employees to increase retention.
Implement the Performance Appraisal Assessment Tool (PAAT) in order to improve performance management and reward processes and actions.
Expand/implement maxiflex, telework, Career Patterns and other programs and flexibilities to assist employees in balancing work and personal responsibilities.*

Performance Measure 1.4 Improve “Leading People” skills of all leaders, supervisors, and managers.

*Indicators:**By FY 2011, AFM will:**Publish and implement Succession Plans in ARS, CSREES, and ERS.
Develop and implement a supervisory training program.***AFM Goal 2: Improved Financial Management****Objective:** REE Agencies sustain a clean audit opinion and have access to quality financial information through financial systems that meet their management needs.**Performance Measure 2.1** REE meets all monthly, quarterly, and annual appropriation level accounting and reporting requirements. Appropriated fund (obligation) and cash reports continue to evidence an accurate financial picture. Reporting difficulties are rapidly resolved.*Indicators:**By FY 2011, AFM will:**Actively respond to annual OIG audit of REE-wide financial statements and resolve audit concerns within established due dates.***Performance Measure 2.2** All REE travelers are supported by a professional, customer oriented Travel and Transportation staff and Web-based systems are operational.*Indicators:**By FY 2011, AFM will:**Implement GovTrip throughout REE ensuring it's operational and documented for end-users.
Conduct GovTrip post-implementation review and effect process changes as necessary.***Performance Measure 2.3** CATS is fully implemented on ARIS/ORACLE platform, meets needs of ARS users, and maximizes opportunities for financial data integration.*Indicators:**By FY 2011, AFM will:**Identify multiple data exchange opportunities between SAMS, ARMPS, CATS, ARIS and other non-financial ORACLE-based applications to reduce the need for duplicate data entry and increase operating efficiency.
Explore and identify data-mining opportunities for ad-hoc reporting from ORACLE-based applications, including software and training requirements.***AFM Goal 3: Improved Real and Personal Property Management****Objective:** Agencies receive effective and automated services for acquisition and personal property management.**Performance Measure 3.1** Acquisition & Property Division, Facilities Division, Area, Locations, and REE agencies partner to effectively implement and administer E-commerce initiatives and custom electronic information exchange.*Indicators:**By FY 2011, AFM will:**Implement new purchase card; Reevaluate the use of the purchase card in ARS (Field); review and determine appropriate number and users of purchase cards.*

Implement USDA CPAIS for personal property in REE.

Performance Measure 3.2 REE Agencies realize cost savings and receive best value through leveraging their energy buying power.

Indicators:

By FY 2011, AFM will:

Coordinate between APD and FD to develop and implement a comprehensive energy buying plan.

Performance Measure 3.3 REE agencies realize cost savings and receive best value through effective fleet management.

Indicators:

By FY 2011, AFM will:

Review vehicle procurements for minimum size needed for mission.

Maximize use of alternative fuels and alternative fuel vehicles.

Monitor fleet fuel use for methods for overall fuel savings.

Performance Measure 3.4 Develop metrics for REE acquisitions.

Indicators:

By FY 2011, AFM will:

Consider ATS or other applications (e.g. the new purchase card system)

Consider any other applications for integration (CATS/ATS)

AFM Goal 4: Improved Accountability and Program Stewardship of the ARS Asset Management Program.

Objective: Stewardship (acquisition, operation, and disposal) of REE Real Property assets effectively supports and enhances the REE Mission Area.

Performance Measure 4.1 Enhance the protection and well being of the work force and REE assets.

Indicators:

By FY 2011, AFM will:

Identify and protect ARS infrastructure and real property assets.

Work with Office of Homeland Security to establish protocols for validating high priority physical security needs.

Analyze trends regarding employee safety and wellbeing with the goal of reducing worker injuries and OMSP exposures to workplace hazards, and implement corrective action.

Performance Measure 4.2 Maintain a robust Real Property Asset Management program.

Indicators:

By FY 2011, AFM will:

Develop and implement a facility Operation and Maintenance Program to address general maintenance, preventive maintenance, and repair of facilities to minimize the life cycle cost of the facility

Exercise proper stewardship of environment, natural, and energy and water resources as defined by EO 13423 – Strengthening Federal Environmental, Energy & Transportation Management.

Utilize the facility plan developed by the Agency and Area Asset Management Review Boards in determining the allocation of R&M funds to meet mission requirements.

Establish a single point of contact in each Area to coordinate the Area's asset management program. Begin the planning and coordination process for the CSREES move from the Waterfront Building.

Performance Measure 4.3 Implement Energy Policy Act (EPACT) 2005 and the Energy Independence and Security Act of 2007

Indicators:

By FY 2011, AFM will:

Establish roles and responsibilities of AFM/Areas/Locations/State Offices in implementing EPACT 2005 and the Energy Independence and Security Act of 2007 goals.

Maximize the use of no cost/low cost energy management programs.

Evaluate how to allocate energy reduction/renewable energy initiatives across ARS in a manner that maximizes progress in meeting Agency EPACT 2005 and the Energy Independence and Security Act of 2007 goals.

AFM Goal 5: Improved Accountability and Program Stewardship of the ARS Extramural Agreements Program.

Objective: Extramural agreements are awarded and administered in an efficient and timely manner to ensure accomplishment of mission and program goals and objectives. All agreements are legally and fiscally sound and are in full compliance with established extramural policies and procedures.

Performance Measure 5.1 Ensure effective use and administration of extramural agreements including fiscal and programmatic responsibility for ADODRs.

Indicators:

By FY 2011, AFM will:

Continue training programs on authorized uses of Extramural Agreements.

Develop automated notification of reporting due dates.

Continue developing awareness of fiscal accountability, and ensure legitimate commitment and sufficiency of funds.

Consolidate interim and annual reporting requirements (AD-421 process).

Performance Measure 5.2 Ensure fiscal and financial systems are fully integrated into the agreement process.

Indicators:

By FY 2011, AFM will:

Develop efficient billing and accounting processes.

Develop process to close agreements in a timely manner.

Review other agencies' business processes for automated agreement account reconciliation and closeout. Consider implementing best business practices.

Performance Measure 5.3 Agreement business processes are measured for effectiveness and efficiency.

Indicators:

By FY 2011, AFM will:

Develop metrics to evaluate agreement process

Measure timeliness of account reconciliation to ensure timely closeouts.

AFM Goal 6: Improved Electronic Access to AFM Information and Business Applications.

Objective: AFM applications fully meet REE needs for administrative and financial management information and guidance in support of improved productivity, service, and reduced costs.

Performance Measure 6.1 Ensure employees have access to personal and professional resources.

Indicators:

By FY 2011, AFM will:

Develop an Executive Information System (EIS), i.e. "Dashboard", with financial, HR, agreements, procurement, property, and facilities data points.

Develop an employee service and information site with career data, personal data, calendars, chat rooms, etc.

Performance Measure 6.2 Ensure that new or modified administrative processes or information systems effect measurable, qualitative improvements.

Indicators:

By FY 2011, AFM will:

Develop an applications enterprise architecture map which identifies the current state and proposed future state of AFM-wide applications (from which to establish priorities).

Identify key business processes most important to HQ, scientists, and

Locations, and which also require the most amount of time and resources, and then focus on two of these processes to automate, integrate, streamline, and improve.

Improve the public AFM Web site ensuring that the information provided is commensurate with agency identified priorities and that access to administrative and financial (AFM) information is clear and user friendly.

ARS Office of the Chief Information Officer (OCIO) Management Initiatives

OVERVIEW OF MANAGEMENT INITIATIVES

ARS works through its Office of the Chief Information Officer (OCIO) to enable more effective and efficient research mission delivery through a strengthened information and technology management program. The premise of this program is based on the following vision statement:

ARS information systems are mission driven and responsive to customer needs; they are reliable, secure, user friendly, relevant, innovative, well planned, and managed effectively.

Effective information systems flow from mission requirements. This relationship dictates a structured, comprehensive, and ongoing review of information systems and the technology needed to support ARS mission and internal and external customer needs. Because ARS is the government entity uniquely responsible for creating new knowledge and the data, information, and technology necessary for a sustainable and globally competitive American agriculture, the Agency's information technology program must provide a safe and reliable environment to support the creation, storage, and dissemination of this knowledge.

The ARS OCIO works in consultation with the ARS Executive Information Technology (IT) Steering Committee to define the strategic direction of the Agency's information technology program in the ARS IT Strategic Plan, which defines ARS' IT strategic goals, objectives, and strategies. The plan identifies key information management issues and provides the framework for developing integrated information systems and technology through further definition and specification of architecture components and information elements. OCIO then works in coordination with the Agency's IT specialists to implement these IT strategies with broad Agencywide impact.

EXPAND ELECTRONIC GOVERNMENT

OCIO facilitates the Agency's implementation of broad Federally and USDA-mandated IT programs focused on expanding electronic government. OCIO will continue to work with the USDA Office of the Chief Information Officer (USDA-OCIO) to achieve this goal. Specifically, OCIO will work with the USDA-OCIO on key areas for effective IT management, such as Enterprise Architecture, Federal Information Security Management Act (FISMA), and Capital Planning and Investment Control, as well as on network efficiency, reliability, and capacity to ensure support of E-Government projects.

Actionable Strategies/Activities for OCIO Management Initiatives

- Ensure that the ARS mission drives its information systems and the deployment of information technology.
- Ensure that ARS information systems are reliable, secure, relevant, innovative, well planned, and managed effectively.
- Invest in appropriate human resources and infrastructure to ensure effective management of high quality information and state-of-the-art technology.
- Ensure information systems support research and technology transfer through development and dissemination of ARS advanced knowledge-based systems, decision tools, and databases.
- Ensure that researchers, educators, and the public have an awareness of and access to research accomplishments and agriculturally related information.