Goal 2: Enhance the Competitiveness and Sustainability of Rural and Farm Economics

New Products/Product Quality/Value Added

*Commercialization of fruit and vegetable food films. New processing technologies are needed to increase the consumption of fruits and vegetables by American consumers. Researchers at Albany, California, worked with an industrial Cooperative Research and Development Agreement (CRADA) partner to commercialize fruit and vegetable based films for application in a variety of food products. In one of these applications, the films function as healthy, colorful alternatives to the seaweed wrap "nori" in a novel line of 7-day sushi-like fusion rolls sold at Costco supermarkets. This year, the films were also introduced commercially into a wide variety of upscale restaurant entrees, and they were used as healthy, flavorful glazes for hams and turkeys. (NP 306, Performance Measure 1.1.2)

*New value added products from biodiesel and soy processing. The recent increase in biodiesel manufacturing has resulted in a surplus of glycerol, a coproduct of the commercial biodiesel production process. Similarly, strong demand in the food sector for soy protein isolates and concentrates has brought about a surplus of soy molasses. To address the need to develop new uses for these coproducts, researchers at Wyndmoor, Pennsylvania, devised fermentation processes to convert them into industrial biosurfactants. They recently achieved a significant increase (up to 3-fold) in product yields through the modification of the fermentation and isolation procedures with soy molasses as feedstock. To test the applications of these biosurfactants in its commercial products, ARS established a CRADA with an industrial partner and filed a patent describing the bioconversion of bioglycerol to these biosurfactants. This bioconversion technology is expected to lower the feedstock cost of biosurfactant production and address the disposal issue faced by the biodiesel and soy processing industries. (NP 306, Performance Measure 1.1.1)

*Expeller pressed low linolenic acid soybean oil--a trans-free alternative to hydrogenated oils.
Food manufacturers and commercial users of frying oils such as restaurants need alternatives to hydrogenated oils for frying because of the trans fatty acid content imparted by hydrogenation. In continuing studies on expeller pressed oils as an alternative to hydrogenated oils, scientists at Peoria, Illinois, found that if low linolenic acid soybean oil is expeller pressed rather than processed conventionally by hexane extraction, the stability of the oil during frying is similar to that of hydrogenated soybean oil. In pilot plant frying studies conducted by the ARS Potato Research Worksite in East Grand Forks, Minnesota, and in batch frying tests conducted at Peoria, scientists found that the combination of expeller pressing and using low linolenic acid soybean oil produced a better frying oil than either expeller pressed regular soybean oil or non-expeller pressed low linolenic acid soybean oil. Oil processors and food manufacturers now have new oil--expeller pressed low linolenic acid soybean oil--as a trans-free alternative to hydrogenation or added antioxidants in edible oils. (NP 306, Performance Measure 1.1.2)

*New applications for USDA-trademarked jet-cooked starch-lipid composites. The FanteskTM process developed by researchers at Peoria, Illinois, was used to prepare a starch-lipid gel that can be reduced in particle size and then blended into low-fat ground meat products, such as beef or turkey. The resulting meat products are healthier for the consumer because of their lower fat content; in addition, their tenderness, juiciness and flavor are similar to those of higher fat products. A CRADA partner and licensee of the technology are currently working with a manufacturer to produce commercial quantities of the FanteskTM product to be marketed under the trade name NutriGras. The product line is being expanded to include ground pork and poultry products. (NP 306, Performance Measure 1.1.2)

*Hydromulch from cotton gin byproducts. Researchers at Lubbock, Texas, working with a CRADA partner, developed a hydromulch out of cotton gin byproducts that was effective at controlling erosion and that provided soil cover equal to, or better than, conventional wood hydromulches. The findings from this research were instrumental in manufacturing the first commercial cotton-based hydromulch product. Hydromulch from this facility is currently being marketed under the trademark name GeoSkin. (NP 306, Performance Measure 1.1.1)

*Kicking up nutrients in melons and incomes in growers pockets. Researchers at Weslaco, Texas, established and transferred technology utilizing foliar potassium sprays to improve the quality of glasshouse-grown melon fruit. During fruiting, the ability of the melon plant's root system to uptake potassium and other minerals is greatly diminished, resulting in an inadequate supply of K necessary for the development of quality compounds: sugars, Vitamin C, and beta-carotene. Researchers, utilizing a novel amino acid complexed potassium compound for foliar

applications during fruit growth and maturation, produced fruit with significantly increased levels of Vitamin C, beta-carotene, and sugar contents, as well as improved fruit firmness and increased shelf life. This accomplishment enables melon producers to efficiently produce more nutritious melons for the consumer and demand a higher price (U.S. Fancy Grade) for their crop. (NP 306, Performance Measure 1.1.2)

*Cotton-based chronic wound dressings. A major unmet need in nursing homes is bedridden and burn patients with non-healing and burn wounds. Researchers at New Orleans, Louisiana, developed a continuous pilot scale process for producing phosphorylated cotton (cotton modified by adding phosphate groups) gauze for new cotton-based wound dressings that will selectively interact with either chronic wounds or burn wounds. In July 2006, the FDA approved the cotton chronic wound dressing for use in patients. The improved wound dressings aid consumers and also benefit cotton farmers and the American textile industry by increasing the volume of value added cotton product sales in the United States.
(NP 306, Performance Measure 1.1.1)

Large scale sequencing of switchgrass and brachypodium. Scientists at Albany, California, were the first to publish gene sequences for Brachypodium, a model grass plant, and switchgrass. These same scientists are also leading national efforts to sequence the entire genome for Brachypodium as well as most of the genes in switchgrass. These latter efforts are funded by DOE's community sequencing program at the Joint Genome Institute. The sequence data generated will accelerate efforts to breed better varieties of perennial, herbaceous energy crops such as switchgrass. (NP 307, Performance Measure 1.1.3)

Enzyme process that enables the commercial production of ethanol from barley. Barley could be converted into ethanol if problems with its high viscosity and low ethanol yields were overcome. Researchers at Wynmoor, Pennsylvania, found that adding beta-glucosidase enzymes to the starch hydrolysis step solves both problems of viscosity and yield. This discovery should enable the building of ethanol plants outside the corn belt and in barley growing regions such as the East Coast, Northwest, and Upper Midwest. Having barley as a viable feedstock could provide an additional one to two billion gallons of fuel ethanol in the United States. (NP 307, Performance Measure 1.1.3)

Producing valuable co-products for corn-based ethanol. Researchers at Wyndmoor, Pennsylvania, determined that treating corn germ with certain protease enzymes such as thermolysin or flavourzyme produces peptides that could act as physiological modulators in the human body. One such effect might lower blood pressure since these peptides inhibit Angiotensin I Converting Enzyme. The ability to produce valuable nutraceuticals from the proteins in corn would improve the long-term business stability of corn-ethanol producers. (NP 307, Performance Measure 1.1.3)

Complete saccharification and fermentation of wheat straw to fuel ethanol. Wheat straw contains 70 percent complex carbohydrate, which can serve as a low cost feedstock for production of fuel ethanol. Batch alkaline peroxide pretreatment, separate enzymatic hydrolysis and fermentation (SHF), and simultaneous enzymatic saccharification and fermentation (SSF) systems have been developed for production of ethanol from alkaline peroxide pretreated wheat straw. Researchers at Peoria, Illinois, have demonstrated that wheat straw pretreated with alkaline peroxide can be completely enzymatically saccharified into fermentable sugars. No common fermentation inhibitors were produced. Both SHF and SSF approaches worked equally well for production of ethanol from the pretreated wheat straw, both systems capitalizing on an ethanologenic recombinant bacterium capable of utilizing multiple sugars (glucose, xylose, arabinose). The research will greatly contribute to the development of an integrated bioprocess technology for fuel ethanol production from lignocellulose.
(NP 307, Performance Measure 1.1.3)

Construction of a proteomic workcell. An automated method to screen large numbers of samples is needed to help identify new microbial strains and enzymes that can be used for efficient production of ethanol and other value-added products from agricultural feedstocks. In cooperation with Hudson Control Group, Inc., Springfield, New Jersey, scientists at Peoria, Illinois, have constructed a plasmid-based functional proteomic workcell for high-throughput assembly, optimization, and modification of gene libraries and microbial strains. Mechanical hardware has been integrated and controlling software developed to provide a robotic platform that picks colonies, cultures bacteria, prepares plasmid DNA, performs in vitro transcription/translation, and assays enzyme activity. This workcell and high-throughput strategy will ultimately be used for identifying strains of ethanologenic yeast capable of fermenting xylose. (NP 307, Performance Measure 1.1.3)

Evolutionary enzyme design for improved biorefining of crops and residues. The current ethanol industry uses a process requiring gelatinization of corn starch at high temperature before the addition of amylases enzymes for starch hydrolysis. Researchers at Albany, California, conducted research under a CRADA with a private sector partner to increase the hydrolysis rate of amylase family enzymes. The result will benefit American farmers, make the fuel ethanol price more competitive, and ultimately alleviate the dependency on imported petroleum. (NP 307, Performance Measure 1.1.3)

Livestock Production

Integrated genetic map developed to aid in assembly and annotation of the bovine genome sequence. Through an internationally funded effort, the Baylor College of Medicine Human Genome Sequencing Center led an effort in generating sequences and assembling the bovine genome sequence into contigs--contiguous sequences of DNA created by assembling overlapping sequenced fragments of a chromosome. ARS scientists at Clay Center, Nebraska, constructed an integrated genetic map comprised of approximately 17,000 markers from several genetic linkage and radiation hybrid maps from around the world. This integrated map was used in the bovine genome sequencing project to serve as the scaffold for assigning sequence contigs to chromosomal positions. In addition, over 1,500 full length cDNA sequences, the gold standards for annotating genes on a genome, were generated and annotated. These accomplishments will greatly accelerate the discovery of DNA markers suitable for marker-assisted selection and fine mapping of genes for economically important traits in cattle. (NP 101, Performance Measure 1.2.3)

Chicken genome sequence enables DNA fingerprinting of commercial and experimental chicken lines. The availability of the chicken genome sequence offers many opportunities to understand complex biological questions, such as how genetic variation influences economically important traits. As a prelude to this advancement, researchers at East Lansing, Michigan, evaluated a large number of chicken lines, including birds from 36 elite commercial lines. By scoring 3,072 SNP markers on 2,580 different chickens, scientists were able to screen the genome for unique or common alleles among the various chicken lines. This result is relevant to scientists and poultry breeding companies as it helps determine what genes are under genetic selection for economically important traits in industry broiler and layer lines. It is now possible to “trace back” poultry products to individual companies and lines through DNA fingerprinting using these markers. An additional aspect of this project is the development of a linkage disequilibrium map of the chicken genome (i.e., haplotype map), which will facilitate the evaluation of whole genome selection methodology. This is the first comprehensive genetic profile of virtually an entire commodity group. This research provides substantial contributions to poultry breeding and food safety. (NP 101, Performance Measure 1.2.3)

Development and validation of marbling prediction for the USMARC Beef Carcass Image Analysis System. A primary determinant of beef carcass value is USDA quality grade, which is largely a function of the degree of marbling as estimated subjectively by USDA graders. Because marbling score determination is subjective, the grading system has been widely scrutinized due to perceived variation in application from plant to plant and among graders within plants. USDA and the beef industry have sought to develop methods to determine beef carcass marbling scores more objectively. ARS scientists at Clay Center, Nebraska, collaborated with an instrument manufacturer to develop accurate methods for marbling score determination as an additional function of the U.S. Meat Animal Research Center (USMARC) beef carcass image analysis system. In collaboration with Agricultural Marketing Service (AMS) scientists and meat grading coordinators, data was collected to develop standards for marbling. Additionally, a series of cooperative studies were conducted to gain AMS approval for use of the USMARC beef carcass image analysis system for marbling determination. This technology, which is expected to have an annual multi-million dollar impact on the beef industry, should benefit consumers and all sectors of the beef industry. (NP 101, Performance Measure 1.2.1).

Respiration rate used as an indicator to determine heat stress in feedlot cattle. ARS researchers at Clay Center, Nebraska, used respiration rate as an indicator to determine risk factors for heat stress in feedlot heifers. It was determined that at temperatures above 25ºC, dark-hided animals were 25 percent more stressed than light-colored animals; a history of pneumonia increased stress level by 10.5 percent; each increase in condition score (fatness)

raised stress level by approximately 10 percent; and excitable animals had a 3.2 percent higher stress level than calm animals. Not only did the stress level increase with these risk factors, but average daily gain was reduced. The results of this study have not only revealed the heat-stress risk factors of breed (color), condition score, temperament, and health history (treated or not treated for pneumonia), but also have shown the effectiveness of using respiration rate as an indicator of heat stress. (NP 101, Performance Measure 1.2.1)

Coumarate-3-hydroxylase (C3H)-down-regulation dramatically alters lignin composition and improves forage digestibility. The lignin component of the plant cell wall limits the ability of dairy and beef cattle to use polysaccharides. Down-regulation of the gene for C3H in alfalfa results in lignin that is derived from 65% of a lignin monomer, p-coumaryl alcohol, which is normally present at very low levels. The compositional and structural changes result in improved digestibility of the plant cell wall. In collaboration with the Noble Foundation who produced transgenic plants for evaluation, ARS scientists at Madison, Wisconsin, performed detailed structural and compositional analysis, and involved the industry in field trials for digestibility. C3H-down-regulation provides a new approach to improving digestibility of forages. A 10 percent improvement in cell-wall digestibility of forages by dairy cows in the U.S. is estimated to annually increase milk sales by $350 million while reducing manure solid production by 2.8 million tons and lowering grain supplement needs by 2 million tons on an annual basis. (NP 101, Performance Measures 1.2.1 and 1.2.2)

Lairage shown to be beneficial to pigs during transport. Research conducted at West Lafayette, Indiana, showed that use of a clean lairage (temporary holding environment) and maintained social structure for a period of 8 hours was beneficial to pigs during transport. Lairage in a known clean environment had benefits of diminished stress and immune stimulation, even 2 weeks after transport. Measures of behavior on the truck, during the lairage, and after the transport showed effects of increased transport stress in continuously transported pigs. Rehydration during the lairage was beneficial and access to feed improved intestinal microbial population stability, potentially altering the ability of the pig to use the nutrients that it eats. These results will aid producers and scientists in managing transported swine more efficiently while simultaneously decreasing losses due to animal stress. (NP 101, Performance Measure 1.2.1)

Identification of quantitative trait loci for bovine pinkeye. Pinkeye is one of the most economically important diseases in cattle. ARS research at Clay Center, Nebraska, has identified two putative quantitative trait loci for this trait, one on chromosome 1 and the other on chromosome 20. A gene known to be involved in pathogen resistance has been located under the quantitative trait loci on chromosome 1. These findings should motivate future studies aimed to identify the genetic base of pinkeye. (NP 101, Performance Measure 1.2.3)

Genetic security of animal germplasm enhanced. The security of U.S. animal genetic resources was significantly enhanced in the past year. Samples in the ARS National Germplasm Collection at Fort Collins, Colorado, increased from 229,110 to 296,555, a 29 percent increase. The collection contains germplasm and tissue samples from 7,322 animals from 25 livestock, poultry, and aquatic species. In addition to collecting samples, the repository released genetic material enabling research in quantitative trait loci discovery, impacting the genetic distancing of cattle breeds, and broadening the genetic base of a rare cattle breed. (NP 101, Performance Measure 1.2.4)

Slick hair gene localized to bovine chromosome 20. The slick hair coat phenotype has been observed in tropical breeds of Bos taurus cattle. It has been found to be beneficial for heat tolerance, often producing body temperatures 0.5° C lower for slick haired animals than for their normal-haired half-sibs during hot summer days. ARS researchers at Brooksville, Florida, conducted a genome scan to map the slick hair gene in Senepol-derived cattle. The gene was localized to a specific region of bovine chromosome 20 bound by two very tightly linked microsatellite markers. The mapping of the slick hair locus is the first step toward the eventual identification of the causative mutation that would constitute the definitive test for the slick hair coat phenotype. The results will facilitate efforts toward introgressing this gene into important temperate Bos taurus breeds (such as Angus and Charolais), to enhance their adaptation to tropical environments. (NP 101, Performance Measure 1.2.3)

Identification of a genomic marker linked with pre- and post-natal growth in beef cattle. A single nucleotide polymorphism (SNP) in the osteopontin gene on bovine chromosome 6 was found to be associated with birth weight, weaning weight, and yearling weight, but not twinning or ovulation rate, in a large multi-generation, cross-bred cattle population at the U.S. Meat Animal Research Center at Clay Center, Nebraska. Frequency of the minor allele in this cattle population was estimated to be 5.2 percent, with the allele producing a difference of 1.14 kg for

birth weight and 5.16 kg for 205-day weaning weight. This polymorphism is a probable functional mutation candidate that successfully tracks functional alleles affecting growth. Marker-assisted selection for the favorable genotype could have a beneficial effect on growth in cattle. (NP 101, Performance Measure 1.2.3)

Discovery of microRNA expression in cattle and swine. MicroRNA genes are a recently discovered form of genetic regulation with enormous impact on a variety of traits including growth, development, and tissue homeostasis. ARS scientists at Clay Center, Nebraska, performed the first survey of microRNA in cattle and swine muscle, and identified similarities and differences between reports from human and mouse muscle microRNA expression profiles. The small RNA fraction containing putative microRNAs was isolated, cloned, and sequenced to identify regulatory molecules. The first experimentally verified cattle microRNA sequences were deposited in the public database, and comparisons with published data from other species were made to identify potential ruminant specific molecules. These results have significant impact on understanding the biology of ruminant muscle, and help scientists address the general problem of annotation and subsequent analysis of the bovine genome sequence. (NP 101, Performance Measure 1.2.3)

New vaccines developed to protect fish from Streptococcal diseases. ARS scientists at Auburn, Alabama, developed novel vaccines to control the bacterial pathogens *Streptococcus agalactiae* and *Streptococcus iniae* in fish. These bacteria have been associated with significant mortalities among a number of freshwater, estuarine, and marine species, causing streptococcal disease that results in more than $100 million in losses annually in cultured fish. Immunization is estimated to profit the farmer by $100 to $300 per acre because fish eat more feed, grow faster, and are less likely to experience mortality from significant diseases. A major pharmaceutical manufacturer is cooperating in a CRADA to commercialize these vaccines for a worldwide market. (NP 106, Performance Measure 1.2.1)

Breeding catfish and rainbow trout to increase disease resistance. ARS scientists at Stoneville, Mississippi, and Leetown, West Virginia, discovered genetic components of resistance to the disease-causing pathogens *Edwardsiella ictaluri* in catfish and to *Flavobacterium psychrophilum* in rainbow trout. Field evaluation is underway for an improved strain of catfish. Scientists have found that the toll-like receptor gene is expressed at a lower level in resistant catfish, and will evaluate the gene as a candidate for marker assisted selection of catfish for survivability. Marker assisted selection could improve the accuracy of selection for this elusive trait. (NP 106, Performance Measure 1.2.1)

Catfish survival improved in hatcheries. Mortality of catfish eggs and fry in commercial hatcheries ranges from 10 to 30 percent of eggs brought to the hatchery, based upon data collected at twenty commercial hatcheries. ARS scientists at Stoneville, Mississippi, and collaborators at Mississippi State University Extension Service determined oxygen requirements of catfish eggs and fry from the current management practices of the twenty hatcheries. Recommendations for hatchery managers were developed and are now in use, and could result in a 10-20 percent increase in fry production by the catfish industry. (NP 106, Performance Measure 1.2.2)

Feeding fish oil to catfish increases highly unsaturated fatty acids (HUFA) in fillets. HUFA have obtained a positive reputation in the medical and human nutrition communities for being healthful. ARS scientists at Auburn, Alabama, demonstrated that the addition of marine fish oil to catfish diets was proportionately reflected in the HUFA content of catfish fillets but had little influence on the performance of catfish. This research may be useful as a marketing tool for catfish, which is not known for being a high source of HUFA. (NP106, Performance Measure 1.2.3)

Revised pond fertilization recommendation improves catfish fry production. Nursery pond fertilization is an important practice among many species of fish to enhance production of phytoplankton and zooplankton needed for development of fry into healthy fingerlings. ARS partners at the Mississippi Agricultural and Forestry Experiment Station in Stoneville, Mississippi, evaluated current practices and found ponds are nitrogen limited, not phosphorus limited as previously believed. New fertilization recommendations developed from this research are being quickly adopted by catfish farmers for more consistent and economical fry production. (NP 106, Performance Measure 1.2.1)

A rapid low-cost test developed for simultaneous and accurate identification of three pathogens. The traditional method of diagnosis requires about a week to arrive at a definitive identification, by which time the opportunity to treat or salvage uninfected stock has passed. ARS scientists at Auburn, Alabama, developed a multiplex-polymerase

chain reaction technique to enable simultaneous and accurate identification of *Edwardsiella ictaluri* (ESC), *Flavobacterium columnare* (columnaris disease), and *Aeromonas hydrphila*, (motile aeromonad septicemia). This test will enable fish farmers to identify the presence of these pathogens within several hours of observing signs of disease or mortalities and to make management decisions to avert the spread of disease. (NP 106, Performance Measure 1.2.1)

Application of behavior to handling fish. Handling and moving is stressful to fish and results in injuries and mortalities. ARS partners at the Conservation Fund Freshwater Institute, Shepherdstown, West Virginia, developed technology, based upon the rainbow trout's ability to sense and avoid carbon dioxide dissolved at elevated levels in water, to move rainbow trout from tank to tank for management purposes or harvesting. This technique is inexpensive, safe, and humane for transferring fish in circular aquaculture tanks. (NP 106, Performance Measure 1.2.1)

Florfenicol is efficacious against *Streptococcus iniae* infection in hybrid striped bass. *Streptococcus iniae* is a major pathogen of hybrid striped bass aquaculture. There are no efficacious vaccines available. ARS scientists at Stuttgart, Arkansas, demonstrated that florfenicol increased survival of infected striped bass from 4 to 94 percent. This research provides data needed for future FDA-approval of florfenicol to treat hybrid striped bass infected with *S. iniae*. (NP 106, Performance Measure 1.2.1)

Crop Production

Discovery of a soybean DNA marker for Asian Soybean Rust Resistance. ARS scientists at Beltsville, Maryland; Urbana, Illinois; and Ft. Detrick, Maryland, and the Monsanto Company have identified a simple sequence repeat (SSR) genetic marker (BARC_Sat_187) that is 99.2 percent accurate in predicting soybean breeding lines that carry resistance to Asian Soybean Rust at the Rpp1 resistance locus. Asian Soybean Rust caused by *Phakopsora pachyrhizi* was first found in the continental United States in 2004, and poses a major threat to the U.S. soybean crop. Four genes in soybean confer resistance to Asian Soybean Rust (Rpp1, Rpp2, Rpp3, and Rpp4), but the utility of these genes in crop improvement has been impeded by a lack of genetic markers. The BARC_Sat_187 SSR marker will be useful for integrating Rpp1 resistance into modern cultivars. (NP 301, Performance Measure 1.2.6)

Plant breeders will be assisted by new genetic methods. Improving agricultural traits using standard genetic mapping approaches and many molecular markers, while faster than traditional breeding methods, can be a slow process. ARS researchers at Ithaca, New York, and Cornell University researchers have developed a new statistical genetic design for dissecting complex traits in corn at the gene level. While standard mapping approaches result in low resolution of complex traits, this new approach, Nested Association Mapping, combines high-throughput DNA sequencing with new statistical approaches that provide very high resolution mapping. These new genetic analysis methods can be extended beyond corn and will be useful for manipulating traits in many types of crops. (NP 301, Performance Measure 1.2.7)

Apple rootstocks modify tree architecture. One of the most critical elements in the establishment of a new orchard is the quality and the architecture (size, number of branches, and branch angle) of the trees that are being planted, since good quality trees enable early productivity and profitability of the orchard. ARS scientists at Geneva, New York, in collaboration with Washington State University scientists and a private nursery, discovered and described how a diverse group of apple rooststocks can predictably modify the branch angle and number of finished trees, thereby increasing the quality of the finished tree. This research also has implications for future mechanization technologies where specific tree architecture is required. (NP 301, Performance Measure 1.2.8)

Crop genetic diversity conserved and distributed to researchers. During FY 2006, the 20-plus genebanks in the ARS National Plant Germplasm System (NPGS) added more than 9,000 separate samples of more than 500 plant species to their collections, creating a total of more than 474,000 samples of more than 11,800 plant species conserved by NPGS genebanks. Scientific interest in this germplasm has increased tangibly during the last few years, with the average number of samples distributed per year now totaling more than 130,000, 30,000 more than the average a decade ago. These materials are keys for continued progress in crop genetics and breeding, which are essential to ensure future food security.
(NP 301, Performance Measure 1.2.8)

Development of bioinformatics tools to construct a physical map of the soybean genome. A genetically anchored physical map of chromosomes is essential for the isolation of genes underlying agronomically important quantitative trait loci. ARS scientists at Ames, Iowa, have built a relational database to hold all of the physical and genetic map data for soybeans. This database can display the physical map overlayed onto the genetic map and is populated with agronomically important quantitative trait loci. In addition, an online tutorial for the Web-based map displays and databases was also developed. This database will be helpful for interpreting whole genome sequence data being generated by the Department of Energy. (NP 301, Performance measure 1.2.6)

Analysis of new wild cocoa germplasm. The mischaracterization of cocoa materials in existing collections and the absence of new accessions of properly characterized wild materials is the single most important factor hampering proper curation and traditional breeding in producing countries. ARS scientists made great strides in identifying wild and previously unknown cocoa varieties by publishing the proper molecular-based labels for 1,124 key accessions of wild Upper Amazonian cocoa and depositing the data in the international molecular database (CocoaGenDB) in Montpellier, France. Analysis and publication of wild populations of cocoa in French Guiana established that they form a very separate and heretofore relatively unknown source of genetic diversity. A substantial number of clones maintained in the two international collections at Costa Rica and Trinidad were profiled (2,047 in total) and submitted to the international phenotypic database in Reading, United Kingdom, and CocoaGenDB. (NP 301, Performance Measure 1.2.8)

Release of the "Sunrise" pear to commercial fruit tree nurseries. The newly released pear variety "Sunrise" fills the need for an early season pear cultivar with excellent fruit quality and appearance and resistance to the devastating disease known as fire blight. Evaluations by ARS scientists at Kearneysville, West Virginia, and cooperators documented excellent overall consumer acceptance in comparison with existing commercial varieties. It is anticipated that "Sunrise" will reduce grower losses and provide good economic return to fruit orchards, especially in regions where the annual risk of fire blight disease limits pear production. (NP 301, Performance Measure 1.2.8)

Development and application of valuable molecular disease diagnostic tests for ensuring the health of plant germplasm. ARS researchers at the NPGS genebanks and their university collaborators developed and/or applied powerful molecular diagnostic tools for ensuring that germplasm is free of key diseases. Examples include molecular diagnostic tests for seedborne Stewart's wilt in maize and bacterial fruit blotch of melons (ARS Ames, Iowa genebank); Citrus leprosis virus (ARS Riverside, California genebank); Phytoplasmas in hazelnut, strawberry, pear, and blueberry (ARS Corvallis, Oregon genebank); alfalfa mosaic virus in crotolaria (ARS Griffin, Georgia genebank); and cucumber mosaic, banana streak, and banana mild mosaic viruses (ARS Mayagüez, Puerto Rico genebank). These molecular diagnostic tests enable rapid, inexpensive, and accurate detection of key pathogens, which is critical for maintaining germplasm health and permitting international and domestic germplasm exchange. Ready access to vigorous and healthy plant germplasm is integral to accelerating progress in crop genetic resource conservation and breeding. (NP301, Performance Measure 1.2.8)

New parental lines of sugarcane. There is a growing interest in development of sugarcane varieties that provide cold hardiness (to increase the range of cane production in temperate climates), have increased sugar, and show potential for use in biofuels. ARS scientists in New Orleans, Louisiana, have developed several new germplasm lines that incorporate *Saccharum spontaneum*, a weedy species of sugarcane better adapted to sub-tropical environments, as the female parent. Several of these lines have sucrose contents that match those of current commercially grown varieties, which trace their ancestry to one female parent incapable of surviving most winters in Louisiana and points north. These lines will be used as parents during the 2006 crossing season to develop sugarcane varieties with improved cane and sugar yields over a range of environments. (NP 301, Performance Measure 1.2.6)

New sunflower germplasm. Four new restorer germplasm lines (RHA 461 to RHA 464) were released by ARS and the North Dakota Agricultural Experiment Station. These germplasm have been selected for their tolerance to Sclerotinia head rot, a major sunflower disease. RHA 462 provides tolerance to Phomopsis stem canker; RHA 464 has resistance to the most virulent North American races of rust and downy mildew. These germplasms are available for use by industry and public researchers to create hybrids, parental lines, or germplasms with increased disease tolerance. (NP 301, Performance Measure 1.2.7)

Identification of proteins associated with Asian soybean rust resistance. ARS scientists at Beltsville, Maryland, identified numerous proteins that may be important to the interactions of soybean with Asian soybean rust (ASR). Researchers used mass spectrometry to identify proteins from rust spores, and found that a majority of the proteins were heat-shock proteins, translation elongation factors, and other proteins. Novel proteins were also discovered, and these proteins may be unique targets for chemical inhibition. The results suggest that an abundance of heat-shock proteins, translation elongation factors, and other protein making machinery enable spores to jump-start protein production upon germination and withstand environmental extremes. These abilities likely help improve a spore's ability to survive and infect plants. This data will aid scientists in identifying soybean proteins and genes involved in susceptibility and resistance to ASR, so that soybean can be engineered with broader resistance to ASR. The protein data will also be of use to scientists at universities, Government agencies, and companies who are designing new fungicides to fight rust diseases. (NP 302, Performance Measure 1.2.6)

Genes identified to improve bioenergy crops. Leaves from grass species, such as corn or switchgrass, are likely to be a significant feedstock resource for a biobased economy. ARS researchers at Albany, California, have cloned the corngrass mutation of maize. Corngrass mutants make many more tillers that are vegetative and have reduced lignin. The researchers have also cloned a maize gene ("milkweed pod") in collaboration with researchers at HortResearch, New Zealand, that regulates tissue and vascular development of the maize leaf. Cloning these genes that affect cell wall content and plant architecture will be an important step toward the development of plant materials with increased energy availability for biofuel production. (NP 302, Performance Measure 1.2.6)

New heat tolerant cotton germplasm with excellent fiber quality. ARS released three improved germplasm lines of upland cotton to the public (jointly with Cotton Incorporated) that possess superior fiber length and strength characteristics and improved yield performance under heat stress environments. Future profitability for U.S. cotton growers requires improvements in fiber quality and plant productivity under abiotic stress, including high heat conditions. The lines provide public and private breeders with resources for concurrent improvement of fiber quality and heat tolerance in upland cottons for the mid-South and Southeastern United States. The lines also serve as genetic resources for improving heat tolerance in Acala cottons of the Southwestern and Western United States. The new germplasm has the potential to impact cotton production over a larger portion of the cotton belt in the U.S. (NP 302, Performance Measure 1.2.6)

New knowledge about nutritional compounds (carotenoids) in fruits and vegetables. Tomatoes are a rich source of carotenoids, which are compounds necessary for human health (precursors to vitamin A) in addition to being strong antioxidants. Understanding the nutritional value of carotenoids requires better knowledge of the complex biochemical pathways that affect the availability and nutritional value of different carotenoids as constituents of the human diet. ARS researchers at Ithaca, New York, have identified a new molecular mechanism involving feedback regulation that governs the carotenoid biosynthetic pathway. This discovery will benefit other researchers and plant breeders who are attempting to modify carotenoid accumulation in crop plants, and it could provide a more effective means for enhancing the nutritional value of carotenoids in fruits and vegetables. (NP 302, Performance Measure 1.2.6)

Determination of genes that affect wheat dough and baking properties. Millers and bakers need high quality wheat, but the elements constituting such wheat are not well understood. ARS researchers at Albany, California, have used wheat biotechnology to determine the effects of two wheat glutenin proteins on dough quality and strength. Researchers also determined the dough mixing properties of transgenic wheat flours that contained increased levels of either glutenin or protein or both. These results can be used to develop wheat lines with a range of dough strengths that could be valuable to the food industry. (NP 302, Performance Measure 1.2.7)

Better to fertilize rhododendron nursery plants in summer than in spring. Fertilizers are commonly applied throughout the spring and summer during the nursery production of rhododendron, even though the timing of plant demand for nutrients was unknown. ARS scientists at Corvallis, Oregon, in collaboration with Oregon State University scientists, determined that nitrogen uptake and uptake efficiency of container grown rhododendron plants were low until July, indicating that fertilizer applied prior to this time may not be effectively taken up by plants. Nitrogen fertilizer management in the production of rhododendron from liner stock should therefore ensure high nitrogen availability during the period of rapid growth in July and August. This information will aid in the development of fertilizer management strategies for nursery container production to decrease fertilizer use and

production costs, improve plant quality, and minimize nitrogen losses to the environment. (NP 302, Performance Measure 1.2.5)

Soybean seeds with improved vitamin E antioxidant content. ARS scientists at Columbia, Missouri, in collaboration with DuPont, Inc., transformed soybeans with a gene for the barley homogentisate geranylgeranyl transferase (HGGT), a gene catalyzes the first step in the synthesis of the tocotrienol form of vitamin E. Gene expression for the barley HGGT under the control of a strong seed specific promoter was accompanied by four to six fold increases in the total vitamin E antioxidant content of soybean seeds. The vitamin E produced in the engineered seeds was principally delta- and gamma-tocotrienol, which are most effective at stabilizing vegetable oils in frying applications. In addition, the increase in total vitamin E antioxidant achieved in these studies greatly exceeds the gains obtained to date by conventional breeding or by biotechnological approaches that have targeted only one gene. It is anticipated that vegetable oils from these genetically enhanced seeds will have improved oxidative stability for food processing and high temperature lubricant applications. In addition, the use of these antioxidant-enriched seeds in livestock feed may result in meats with improved appearance and shelf life. End users of these seeds will likely include soybean oil processors and biobased lubricant manufacturers. (NP 302, Performance Measure 1.2.6)

Heat tolerance genes identified. ARS scientists at Lubbock, Texas, have identified two genes (digalactysyldiacylglycerol synthase and AtFtsH11 protease) that contribute to basal heat tolerance in plants. This discovery advances understanding of the cellular components impacting heat tolerance, and in combination with additional gene discoveries, will allow scientists to develop more heat-tolerant crops. (NP 302, Performance Measure 1.2.6)

Winter protection technique for blackberries. When temperatures drop below -15C, blackberry canes and buds can be damaged, resulting in low productivity. Scientists at the Appalachian Fruit Research Station, Kearneysville, West Virginia, developed a novel technique to mitigate winter injury, which involves a rotating cross-arm trellis system and cane training technique reorienting a vertical summer canopy to a low profile canopy in winter without breaking canes. The studies showed that even cultivars developed in the Pacific Northwest such as "Siskiyou," a USDA release, produced 3 to 4 times more fruit than unprotected plants and blackberry plants that were covered in winter and produced fruit 2 to 3 weeks earlier. This production technique enables blackberries to ripen during the red raspberry season and can help to extend the harvest season. The new cropping system improves farm diversification and enhances the grower's competitive advantage by allowing the blackberry growers to produce a variety of berry crops for niche markets. (NP 305, Performance Measure 1.2.5)

The Honey Bee Genome: honey bee immune response may reduce reliance on commercial antibiotics. Using genomic approaches, ARS scientists have showed that harmless bacteria can induce an immune response that proves helpful in warding off infection by a disease-causing bacterium in honey bees. This research addresses the need for understanding the underlying basis for bee responses to disease agents, and has already led to findings by ARS scientists that the bee has a less developed immune response than any other insect, perhaps relying on more socially-related hygienic behavior for colony protection against diseases. (NP 305, Performance Measure 1.2.5)

Predicting spray drift. One of the most severe problems that pesticide applicators face is spray drift, which results in airborne droplets of pesticide reaching unintended targets. Complaints regarding spray drift are routinely brought to state departments of agriculture, and in some cases even lead to court cases. By using the computer program, pesticide spray applicators can calculate drift potentials before applying sprays or making changes to spray practices and equipment to keep drift potential at a minimum level. A user friendly computer program was developed and released by ARS scientists at Wooster, Ohio, to predict spray drift potential from ground spray applications. This program has been used worldwide by many researchers, educators, sprayer manufacturers, and other agencies since it was released. The program has also been used in courts to adjudicate lawsuits on drift damages to neighboring crops. (NP 305, Performance Measure 1.2.5)

Discovery of a means for using RNA silencing (RNAi) in honey bees is systemic. After years of study, ARS scientists have shown that soaking or feeding bees with a new class of regulatory compounds leads to changes in bees' genetic response. Further, use of the RNAi technique will allow researchers to investigate involvement of a specific gene (*e.g.*, genes for resistance to diseases and parasites, reproduction, or ability to pollinate crops) by turning off the expression of that gene of interest and observing the effects on the bee. (NP 305, Performance Measure 1.2.5)

Continuous vineyard tracking with the Trellis Tension Monitor. The Trellis Tension Monitor, U.S. Patent No. 6,854,337, was developed by ARS scientists at Prosser, Washington, and has been exploited for its sensitivity to subtle changes in trellised vineyards due to vine growth, fruit growth, and certain farming practices that influence the weight that is borne by the trellis wire. This technology can be used to estimate, in real time, information that is important to growers and processors for making decisions about irrigation, crop thinning, and supplemental manual sampling. Access to continuous information about the status of the vineyard will allow growers to continuously adjust some of their farming practices as the crop responds to the weather, irrigation, or other inputs. Currently, information at this temporal resolution is not available to growers, processors, or wineries from existing technologies. The Trellis Tension Monitor is applicable worldwide to any trellised crop in which there is a significant weight-bearing wire integral to the trellis system. (NP 305, Performance Measure 1.2.5)

Increasing berry antioxidant capacity and shelf life. ARS scientists at Beltsville, Maryland, found that natural volatile compounds such as methyl jasmonate, an essential oil of tea tree, applied immediately after harvest are effective in promoting the antioxidant capacity and antioxidant enzyme activities in berry fruits. These natural products also retarded decay of berry fruit during storage. Therefore, it is possible that the health benefits and the shelf life of these berry fruits can be improved by postharvest exposure to certain natural volatile compounds. (NP 305, Performance Measure 1.2.5)

New mechanism of sunburn damage in fruit crops. Sunburn is a common disorder of high value crops in tropical, subtropical, and temperate climates and is related to: 1) high fruit temperature, 2) high visible light intensity, 3) ultraviolet radiation, and 4) positional changes in fruit that expose them to conditions different from those to which they are adapted. The interaction of high fruit temperature, high light levels, and short term UV exposure were examined by ARS scientists at Kearneysville, West Virginia. All tropical fruit and the apple cultivars Gala, Gold Rush, and Granny Smith increased respiration when challenged with UV, suggesting that UV repair mechanisms are induced and functioning with no adverse effect on photosynthesis. In contrast, Braeburn apple, a sunburn sensitive cultivar, lacked increased respiration and had reduced photosynthesis. The pattern suggests that when UV repair mechanisms are effective, photosynthesis is adequately protected, and the protection occurs at the cost of higher respiration. This information will be useful in evaluating germplasm for sunburn resistance. (NP305, Performance Measure 1.2.5)

Largest, most complete pollinator survey shows trends in bee population levels. While managed bees are critical to U.S. agriculture, little is known about the abundance and diversity of native, wild bees that not only contribute to crop pollination, but also maintain the diversity of our native plant species. ARS scientists have concluded a survey of bees in the Grand Staircase-Escalante National Monument. This survey has allowed for the analysis of patterns of specialization and generalization among bee species. There were 643 species discovered within this monument, making it the richest bee landscape ever studied to date. The information gleaned from this survey will lead to a greater understanding of native pollinators during a time of heightened concern about the declining pollinator population. (NP 305, Performance Measure 1.2.5)

Terroir of Idaho's Western Snake River Plain. Potential viticultural sites in the western Snake River Plain of Idaho were identified and characterized. A geological and climatic comparison of the Snake River Valley in Idaho to more established production regions was made by ARS scientists at Parma, Idaho, in collaboration with the Idaho Geological Survey, Boise State University, and the wine industry. The resulting publication was used by the Idaho Grape Growers and Wine Producers Commission to petition the Alcohol and Tobacco Tax and Trade Bureau for a designated American Viticultural Area (Federal Register 71(136) July 17, 2006). (NP 305, Performance Measure 1.2.5)

Goal 4: Enhance Protection and Safety of the Nation's Agriculture and Food Supply

Food Safety

Detection and fingerprinting of *E. coli* O157:H7 in California agricultural environments. Numerous outbreaks of *E. coli* O157:H7 have been linked to produce grown and processed in California. Knowledge of the epidemiology and

ecology of *E. coli* O157:H7 in this agricultural environment is critical for preventing contamination of raw produce in the fields. ARS scientists in Albany, California, in collaboration with the California Department of Health Services, Central Coast Regional Water Quality Control Board, and FDA, sampled numerous watershed sites in Salinas Valley, California. Multiple *E. coli* O157:H7 strains, sources of dissemination, and persistence related to the watershed were identified. This information was critical to the industry and regulatory agencies in their analysis of the recent spinach related *E. coli* O157:H7 foodborne illness outbreak. (NP108, Performance Measure 3.1.2)

Preharvest strategies devised to kill Salmonella, Campylobacter, and *E. coli* O157:H7. Foodborne pathogens can live in the gastrointestinal tract of food animals. Researchers from College Station, Texas, and Athens, Georgia, have devised diverse strategies to reduce pathogenic bacteria in food animals during the production chain. An antimicrobial protein was discovered that reduces Salmonella infections in egg-laying chickens by stimulating the birds' own immune system. As a feed additive, this protein shows great promise in reducing Salmonella in poultry and is being subjected to further real world testing. Other researchers have shown that the addition of a bacterial protein (called a bacteriocin) can reduce Campylobacter populations in chickens. In cattle and swine, the pharmaceutical product Ractopamine that is used to promote growth and increase lean muscle mass was found to reduce *E. coli* O157:H7 intestinal colonization and fecal shedding in feedlot cattle. All of these pathogen reduction strategies are important because they do not use traditional antibiotics, which increase antibiotic resistance. (NP 108, Performance Measure 3.1.1)

Handheld imaging devices. Scientists at Beltsville, Maryland, designed two handheld portable inspection devices equipped with head mount displays and wireless image-voice central communication capabilities for sanitary inspections of food processing plants. The technology has applications for the inspection of foods and processing plant sanitation, such as for fecal contamination on stainless steel plates that are typically used for manufacturing plant equipment. Various food safety regulatory agencies, security agencies, and commodity organizations have shown considerable interest in the technology. A U.S. patent application for the technology has been submitted. (NP 108, Performance Measure 3.1.2)

Detection of E. coli O157:H7 and Salmonella. In order to quantify the risks associated with the slaughter of animals that may harbor or shed E. coli O157:H7 or Salmonella species, accurate estimates of the prevalence and frequency of pathogen distribution and relative concentration on hides and in feces is needed. ARS scientists at the Clay Center, Nebraska, developed two methods for the direct enumeration of E. coli O157:H7 and Salmonella species. Use of the methods for pathogen enumeration data, in combination with pathogen prevalence, will provide processors and regulatory agencies with greater control of potential pathogen contamination and further improve the safety of beef for consumers. (NP 108, Performance Measure 3.1.2)

Live or dead bacteria. There is a need to differentiate between live and dead bacteria in foods. Scientists at Wyndmoor, Pennsylvania, in collaboration with Purdue University, have developed a test using specialized spectroscopy methods to readily differentiate live versus dead cells of E. coli O157:H7. This test permits rapid differentiation for cells killed by the various processing techniques used in industry. Because of the relative speed of this multi-step procedure, large numbers of cells could be quantitatively analyzed. Regulatory agencies will greatly benefit from the implementation of this technology. (NP 108, Performance Measure 3.1.2)

Flies and transport trays can spread *Salmonella* and *Campylobacter* in poultry. *Campylobacter* and *Salmonella* are the two most common food-borne pathogenic bacteria affecting the U.S. and are both associated with poultry; they cost the U.S. economy approximately $4 billion per year in direct and indirect costs. Scientists in Athens, Georgia, and Gainesville, Florida, found that flies could transmit *Salmonella* through direct surface contact or being eaten by hens. Researchers found that flies could spread *Salmonella* between rooms and houses that have been decontaminated. Other scientists in College Station, Texas, found that the tray liners used to transport newly hatched chicks from commercial hatcheries could contain *Campylobacter*, thus serving as a vector to the newly hatched bird. Combined, the results of these research projects suggest two new critical control points where we can attack the spread of *Salmonella* and *Campylobacter* on the farm. (NP 108, Performance Measure 3.1.1)

Soil cadmium can be concentrated in lettuce. Some trace elements such as cadmium, lead, and arsenic can be transferred to crops when they are grown on mineralized or contaminated soil. International sales of some foods, such as sunflower kernels, flax, durum wheat, and Romaine lettuce, have been limited by high natural crop cadmium

levels. Researchers in Beltsville, Maryland, characterized cadmium accumulation in lettuce and spinach grown in specific soil types (Lockwood and marine shale parent rocks) and found that lettuce from these studies would violate international limits for leafy vegetables if such limits were established. These studies demonstrate the need for technologies that can phytoextract cadmium from soils or can reduce cadmium uptake and accumulation in lettuce and spinach. (NP 108, Performance Measure 3.1.1)

Radiation inactivation of furan and acrylamide in foods. Furan and acrylamide are chemicals of concern found in many thermally processed foods. Scientists at Wyndmoor, Pennsylvania, conducted studies to determine if ionizing radiation could decrease the amount of furan and acrylamide in various foods. Low dose ionizing radiation significantly reduced furan levels in ready-to-eat meats, but had a limited effect on the inactivation of acrylamide in oils and potato chips. This data will directly assist the Food and Drug Administration in evaluating a petition currently under review to allow irradiation of ready-to-eat foods. (NP 108, Performance Measure 3.1.2)

Norwalk virus detection. Norwalk virus cannot be cultured, and therefore detection relies on capture and concentration of the virus. Scientists at Albany, California, developed a novel Polymerase Chain Reaction (PCR) method involving an immunochemical capture step and real-time PCR (rtI-PCR). The sensitivity of this rtl PCR technology is significantly increased over the standard ELISA and traditional reverse transcriptase (RT) PCR for the detection of virus in stool and food samples. Public health agencies have a critical need for simpler, faster, and more sensitive detection methods for this common viral food contaminant. (NP 108, Performance Measure 3.1.2)

Mycotoxin detection methods developed to make toxin identification easier. There are a wide variety of mycotoxins that are structurally different and have different modes of action. The differences in toxin structure makes identification of the specific toxin involved in illnesses or crop death difficult and time consuming. Researchers in Peoria, Illinois, have synthesized and characterized molecularly imprinted polymers that bind the mycotoxin moniliformin. The synthesis of the imprinted polymers will allow for rapid diagnostics and for evaluation of strategies to bind toxins in feeds, foods, and humans. Other researchers at Peoria have produced monoclonal antibodies that recognize the mycotoxins nivalenol and vomitoxin. These antibodies can be used simultaneously to screen corn, wheat, and barley for these important toxins through a simple ELISA test, and prevent them from affecting humans, animals, or plants. (NP 108, Performance Measure 3.1.1)

Petting zoo livestock not burdened with pathogenic bacteria. Salmonella, *E. coli* O157:H7, and related bacteria are some of the most critical food safety issues because of the severity of illness they cause in children and the elderly. Petting zoos are designed to expose children to animals, including livestock, but in several cases they have exposed children to pathogenic bacteria. Clay Center, Nebraska, researchers surveyed more than 1,000 animals in 25 States and demonstrated that the prevalence of these pathogens in petting zoo livestock with human-animal contact was less than 0.6 percent. This is contrasted with the 20-fold higher incidence in commercially reared livestock or livestock displayed at agricultural fairs. The results indicate that preharvest control of pathogenic bacteria is indeed possible. (NP 108, Performance Measure 3.1.1)

Antioxidants reduce aflatoxin concentrations in tree nuts. Tree nuts sales are estimated at $2 billion per year; approximately 60 to 70 percent of the crop is exported. Aflatoxin is a serious threat to human health and agricultural trade because it is a potent natural carcinogen produced by a fungus. Levels of aflatoxin in tree nuts are closely monitored by importing nations. Research in Albany, California, has demonstrated that some antioxidants reduce fungal synthesis of aflatoxin by enhancing the natural breakdown of aflatoxin by the fungus that produces it. Antioxidant levels can be increased through selective breeding or direct application to tree nuts, making them safer for consumers and more acceptable to trading partners.
(NP 108, Performance Measure 3.1.1)

Livestock Protection

Genetic indicators of leptospiral evolution. Leptospirosis is one of the most common zoonotic diseases in the world, resulting in high morbidity and mortality in humans and affecting global livestock production. Most infections are caused by either *Leptospira borgpetersenii* or *Leptospira interrogans* bacteria that vary in their distribution in nature and rely on different modes of transmission. ARS scientists at the National Animal Disease Center in Ames, Iowa, and colleagues in Australia reported the complete genomic sequences of two strains of *L. borgpetersenii serovar*

Hardjo that have distinct phenotypes and virulence. Most interestingly, the *L. borgpetersenii* genome is ~700 kb smaller than *L. interrogans*. Loss of gene function is not random but is centered on impairment of environmental sensing and metabolite transport and utilization. These features distinguish *L. borgpetersenii* from *L. interrogans*, a species that survives extended passage in aquatic environments before encountering a mammalian host. Unlike other leptospiral strains that depend on the environment for transmission, this landmark study indicates that *L. borgpetersenii* is evolving toward dependence on a strict host-to-host transmission cycle. The results of this study provide new targets for vaccine and drug development against this important pathogen. (NP 103, Performance Measure 3.2.1)

Comparative genomic analysis of *Mycobacterium paratuberculosis* (Johne's disease) isolates from multiple host species. Scientists at the National Animal Disease Center (NADC) in Ames, Iowa, capitalizing on the completion of their work sequencing the whole genome of *M. paratuberculosis* (bovine isolate K10), are now conducting comparative microbial genomics studies. The researchers are identifying unique sequences to generate diagnostics to study the epidemiology and ecology of *M. paratuberculosis*. They isolated the genomic DNA from 35 *M. paratuberculosis* isolates and compared them to the sequenced *M. paratuberculosis* K10 isolate by competitive hybridization to DNA microarrays. Isolates were obtained from a variety of host species, including cattle, goats, sheep, bison, starlings, and humans. Analyses of the data generated from these studies is revealing that *M. paratuberculosis* isolates from sheep can be characterized by a series of inserted and deleted gene clusters, while the isolates obtained from other host species are highly similar to the sequenced isolate *M. paratuberculosis* K10. These findings will allow us to develop a more comprehensive understanding of the genetic diversity present among *M. paratuberculosis* isolates and may answer questions of transmission of *M. paratuberculosis* from one species to another, along with environmental and host pressures on the evolution of the microorganism. (NP 103, Performance Measure 3.2.1)

Inactivated Avian Influenza (AI) vaccines provide protection against Asian H5N1. Inactivated AI vaccines have been used in Asia for the past four years to control H5N1 highly pathogenic AI,(HPAI) but there are concerns that changes in the virus (caused by antigenic drift) may make these vaccines less protective. ARS scientists at Athens, Georgia, determined that several H5 vaccines that have been used or that are commercially available were still protective against a 2006 H5N1 HPAI virus isolated from a chicken in Hong Kong. The vaccine protected chickens from clinical signs and death when challenged with high doses of the 2006 H5N1 HPAI virus. In addition, the vaccine reduced the growth of the challenge virus in vaccinated chickens with no detectible shedding from the intestines and reduced shedding from the respiratory tract. These data indicate the inactivated H5 AI vaccines available for poultry provided excellent protection against the 2006 Hong Kong strains of H5N1 HPAI virus. (NP 103, Performance Measure 3.2.1)

Abnormal prion accumulation associated with retinal pathology in sheep with scrapie. A study completed by ARS scientists at the National Animal Disease Center in Ames, Iowa, in collaboration with Iowa State University demonstrates that the retina responds to the accumulation of abnormal prion protein in a way that may affect visual system function. In their study of scrapie-infected sheep, scientists found that abnormal prions accumulating in the retina were immunoreactive, demonstrating that specific cell populations of the retina were affected. This study provides the first report that a prion disease in a natural host causes the accumulation of abnormal prions in the retina that is associated with disease, in the absence of overt changes in the retina that are normally indicative of retinal degeneration. This study provides additional information on abnormal prion tissue migration, and may provide new opportunities for early detection of prion diseases in animals prior to clinical signs. (NP 103, Performance Measure 3.2.1)

In vitro model developed for determining the virulence of BVDV strains. Different strains of Bovine Viral Diarrhea Virus (BVDV) cause different disease syndromes, some causing very severe clinical disease and some causing very mild clinical disease. To date, the only way to determine if a virus caused severe disease (*i.e.*, was a virulent virus) or caused mild disease (*i.e.*, was an avirulent virus) was to infect animals with the virus and observe the results. This limited the research that could be done to determine why some viruses were virulent and others avirulent. ARS scientists at the National Animal Disease Center in Ames, Iowa, developed a model that uses cultured cells rather that live animals to differentiate between virulent and avirulent viruses. This model may reduce the need to use live animals and will significantly cut the cost and difficulty of studying virulence in BVDV strains. Preliminary results generated with this model indicate that BVDV virulence leads to the death of cells associated with the immune system. (NP 103, Performance Measure 3.2.1)

Understanding the role of hypocalcemia in dairy cows and disease susceptibility. Hypocalcemia (low blood calcium) is common in periparturient dairy cows and is associated with decreased intracellular calcium (Ca) stores in peripheral blood mononuclear cells (PBMC). ARS scientists at the National Animal Disease Center in Ames, Iowa, completed studies suggesting that this is caused by a blunted intracellular Ca release response to an immune cell activation signal, a suppression of the immune system. Researchers concluded that intracellular Ca stores decrease in PBMC before parturition and the development of hypocalcemia, suggesting that systemic calcium stress precedes measurable hypocalcemia, particularly in cows that will develop milk fever. Therefore, in transition cows, PBMC intracellular Ca stores are a more sensitive measure of calcium stresses than calcium levels in the blood. Furthermore, this decrease in PBMC intracellular Ca stores before parturition and the development of hypocalcemia contributes to periparturient immune suppression, supporting a link between decreased Ca and suppression of the immune system. This research leads to a more complete understanding of the role of hypocalcemia in the complications of a hypocalcemic episode, such as increased disease susceptibility, and will lead to a better detection system that can reduce the frequency of milk fever. (NP 103, Performance Measure 3.2.2)

Genetically controlled incubation period of Chronic Wasting Disease (CWD) in elk. CWD is a member of the Transmissible Spongiform Encephalopathy (TSE) family of disorders that includes Scrapie, Bovine Spongiform Encephalopathy (BSE), and Creutzfeldt-Jacob disease. CWD is a relatively uncharacterized TSE with novel patterns of transmission and agent distribution, and represents the considerable challenge of controlling a persistent disease in free ranging wildlife. CWD in North America has resulted in the loss of domestic and foreign markets, restrictions on trade and movement of live animals, and substantial costs associated with the surveillance of hunter-killed animals. ARS scientists at Pullman, Washington, working in collaboration with the ARS National Animal Disease Center in Ames, Iowa, Colorado State University, and APHIS Veterinary Services and Wildlife Services, documented the first association between the Prnp codon 132 genotype and the incubation time in elk with experimental CWD. The research characterized the disease phenotype in elk as either homozygous or heterozygous for the highly susceptible Prnp allele, and demonstrated that there were no differences in the eventual outcome of the disease, only in the incubation period. This information will be useful for producers and regulatory groups in establishing minimum quarantine periods and elk movement requirements and in providing guidance to investigators performing pathogenesis trials. (NP 103, Performance Measure 3.2.2)

Control of fire ants without chemicals. Imported fire ants ruin pasture land, disrupt agriculture, and seriously injure people over an area of 300 million acres in fifteen States and Puerto Rico. ARS scientists at Gainesville, Florida, and Stoneville, Mississippi, have greatly expanded the usefulness of biocontrol agents (*i.e.*, insects and pathogens that kill fire ants). Researchers have continued to facilitate the distribution of tiny flies that parasitize the ants, documenting their spread in Alabama, Oklahoma, and Tennessee. In addition, scientists have characterized the first virus ever discovered in fire ants and discovered a new species of roundworm that kills the ants. Other workers are searching in South America for new biocontrol agents and using modern genetics to match those organisms to populations of fire ants. As the new insect and pathogen enemies of fire ants become established across the Southeastern United States, they will form a natural complex that will lower the number of fire ants to more tolerable levels. As the number of fire ants is reduced, native ants will move into unoccupied habitats, providing further control and improving biodiversity. (NP 104, Performance Measure 3.2.1)

New insecticides to protect deployed warfighters. Military personnel deployed overseas are particularly susceptible to diseases that are transmitted by insects, ticks, or mites. ARS scientists have been funded by the Department of Defense to work toward the development of new insecticides. Working at Beltsville, Maryland; Gainesville, Florida; College Station, Texas; and New Orleans, Louisiana, chemists and entomologists have invented four entirely new insecticidal chemistries and discovered that two existing pesticides might have applications for preserving public health. After performing the basic work to identify these new insecticides and test their range of uses, ARS will hand off the chemicals to industry for development and marketing. The military will be able to use these new registered insecticides to help safeguard their deployed forces. (NP 104, Performance Measures 3.2.1 and 3.2.3)

Successful biological treatment of termites in living trees. The Formosan Subterranean Termite is a devastating pest of property and trees, nesting in the ground, walls, or in living trees. Treatment of trees is particularly difficult because of poor access to the interior and the challenge of detecting the termites within. ARS scientists at New Orleans, Louisiana, working in collaboration with academia, industry, and local government, performed research showing that termites could be detected by their unique head-bumping sounds. A device was developed to listen for

the termites in trees, and was successfully applied to show that 60 percent of trees in a portion of New Orleans were infested. Trees were successfully treated using an ARS-developed procedure of applying keratin-based foam with spores of an insecticidal fungus. This procedure provides the pest control industry with a safe, efficient way to eliminate Formosan Subterranean Termites from trees. Combined with other control techniques, this development increases the possibility of eradicating the termites from local areas. (NP 104, Performance Measure 3.2.1)

Discovered details of biting midge saliva. Biting midges transmit bluetongue and vesicular stomatitis viruses to cattle and other ruminants. These infections affect the health of the animals and greatly complicate what should be routine movement of animals for trade. Scientists at Laramie, Wyoming, have accomplished the nearly impossible by extracting saliva from these tiny insects and then analyzing its components. The result has been an impressive variety of proteins, many of which have strong physiological effects on mammals that are bitten. These basic discoveries will lead to new ways to protect cattle from biting midges and possibly provide better control techniques for other species that bite humans. (NP 104, Performance Measures 3.2.1 and 3.2.3)

Cutting edge research on tick physiology. Ticks are a major threat to the livestock industry and to human health, because particular species transmit pathogens that cause serious diseases. Some of those diseases are already a problem, and others could be introduced to the United States with disastrous results for the agricultural economy. ARS scientists at Kerrville, Texas, and College Station, Texas, in collaboration with academic institutions and industry, have analyzed the mechanics of tick physiology to discover the DNA sequences responsible for pesticide resistance, susceptibility to disease transmission, and essential metabolic processes. This work has opened an entirely new range of possibilities for tick control. Salivary components of ticks have been identified and genetically defined, creating candidates for anti-tick vaccines. Scientists described the first signal transmitter chemicals of the tick brain, establishing a new mode of action for toxicants. Researchers used the sequence of genes that produce insecticide resistance enzymes as the basis for the development of rapid tests to determine an infestation's susceptibility to a particular treatment. The products of this research provide the advances necessary to maintain the current barrier against cattle fever, keep diseases like heartwater out of the U.S., and prevent tragic human illness from Lyme disease and other pathogens. (NP 104, Performance Measures 3.2.1 and 3.2.3)

Reduction in environmental and monetary costs of sterile screwworm production. The screwworm fly was a devastating pest of cattle and other livestock throughout the southern and central U.S. until the 1950s. At that time, USDA developed a plan to eliminate the fly by releasing billions of sterile male flies, overwhelming the reproductive systems of the species. The program has progressed to the point that the screwworm fly has been eradicated all the way south to Colombia. To maintain this barrier, billions of flies must be reared, sterilized, and released. Until this year, the diet for rearing the immature flies (maggots) included a gelling agent that made the mix palatable to the flies. The gelling agent was expensive and had to be disposed as hazardous waste. ARS scientists working at the Screwworm Research Unit in Tuxtla-Gutierrez, Mexico, developed a cellulose-based diet that used ground-up newsprint instead of the gelling agent. The diet has been adopted by the fly-production plant and saves approximately $300,000 per year, in addition to preventing an environmental problem. (NP 104, Performance Measure 3.2.1)

New ways to control Horn Flies. Horn Flies are a particularly destructive pest of cattle. They ride along on the cow taking frequent bloodmeals, leaving only to quickly lay eggs on a fresh cow pat. Some estimates attribute over $700 million in damage to cattle per year to this fly in the United States. Current control techniques rely on the liberal use of insecticides, to which the flies frequently develop resistance. ARS scientists at Kerrville, Texas, have been making progress toward understanding and finding new ways to control Horn Flies. They have assembled a database of cattle DNA associated with either susceptibility or lack of susceptibility to the Horn Fly. Collaborating with the Areawide Pest Management Research Laboratory in College Station, Texas, they discovered a brain signal chemical in the fly that performs its essential physiological functions. In addition, they were able to control the fly by dusting cattle with the spores from a fungus that is toxic to the insect but not the cow. These discoveries will lead to more sophisticated control techniques that will be combined to manage the Horn Fly in a sustainable, environmentally-friendly way.
(NP 104, Performance Measure 3.2.1)

Targeting mosquitoes for control. The threat of mosquito-borne diseases that already exist in the U.S., like West Nile, or diseases that might be introduced, like Rift Valley fever, has raised awareness of the need for community mosquito control. Each mosquito abatement district tends to know its own area well, but areas between districts or

areas where new districts should be formed may have large concentrations of mosquitoes in some parts. Scarce control resources need to be targeted according to the threat. ARS scientists at Gainesville, Florida, and Laramie, Wyoming, working in cooperation with academia, mosquito abatement districts, State governments, and other Federal agencies, have assembled a series of models of mosquito distribution that range from continental to local scale. Following further development and distribution, these models, combined with temperature-based models of disease transmission risk, will be an essential tool for decision makers to determine what areas are in greatest need of mosquito control resources, in order to use those resources to have the greatest impact against disease transmission. (NP 104, Performance Measures 3.2.1 and 3.2.3)

Crop Protection

Development and deployment of a rapid PCR-based assay for citrus greening. The arrival of citrus greening, Huanglongbing, represents a serious threat to citrus production in Florida. ARS scientists at Beltsville, Maryland, developed and validated the first real time, quantitative PCR assay for the greening pathogen. This assay was used by APHIS and the Florida Department of Agriculture to confirm the presence of citrus greening in Florida. Producers will benefit from early detection, and genetic improvement for resistance will be accelerated. (NP 303, Performance Measure 3.2.3)

Sources of resistance to soybean rust identified. Soybean rust, *Phakopsora pachyrhizi*, can drastically reduce yields and increase production costs for U.S. producers. Yield losses in some countries in Africa, Asia, and South America have been significant, and since the report of soybean rust in Hawaii in 1994, ARS has renewed its support for soybean rust research. ARS scientists at Ft. Detrick, Frederick, Maryland, screened over 16,000 soybean accessions in the USDA Germplasm Collection located at Urbana, Illinois, and evaluated them for resistance to *P. pachyrhizi* in Biosafety Level 3 containment greenhouses. In analyzing these accessions, scientists identified many new sources of resistance, which may provide the resistance genes needed for future development of soybean cultivars with soybean rust resistance. This information will be critical to soybean researchers who are interested in sources of resistance to soybean rust. (NP 303, Performance Measure 3.2.5)

Rapid detection of eight viruses that infect wheat with one test. Barley and cereal yellow dwarf viruses (five strains), wheat spindle streak mosaic, wheat soil-borne mosaic virus, and wheat streak mosaic virus represent the most economically important group of viruses that infect wheat. ARS researchers at West Lafayette, Indiana, have developed a single, rapid test that can simultaneously detect all eight viruses. Development of this assay enables rapid and accurate diagnosis of the cause of wheat disease damage, allowing producers to benefit from early detection and accelerating genetic improvement for resistance. (NP 303, Performance Measure 3.2.3)

New Fire Blight biocontrol agent approved for use in the United States. Fire blight is a serious disease of apple and pear trees caused by a bacterium. ARS scientists at Wenatchee, Washington, utilized new techniques for evaluating beneficial microorganisms on blossoms, the site of primary infections. This led to the discovery of *Pantoea agglomerans* strain E325, an effective biocontrol agent, and to a patent license agreement with a private company that has interest in its commercial development. Research cooperation with the company from 1999 has led to improvements in fermentation and formulation methods, establishment of effective field rates, and information required by regulatory agencies in the United States and Canada. In September 2006, a formulated product consisting of E325 as the active ingredient was fully registered with the EPA, allowing its availability to fruit growers for fire blight management during the spring of 2007 and creating the potential for improved control of this disease. (NP 303, Performance Measure 3.2.5)

Release of JTN-5503 soybean germplasm line. ARS scientists at Stoneville, Mississippi, have released the advanced breeding line JTN-5503 with resistance to soybean cyst nematode, frogeye leaf spot, stem canker, and charcoal rot. The soybean cyst nematode is a serious pest of soybean in all the soybean production regions in the United States, and public soybean breeders have identified resistance to this pest as a major breeding objective; the other diseases can also cause significant yield losses. JTN-5503 was grown in nine States in the USDA Southern Uniform Tests program in 2004 and 2005 and was one of the two top yielding entries in its maturity group. Soybean breeders will use this germplasm line as a parent to develop soybean varieties for soybean producers. (NP 303 Performance Measure 3.2.4)

Sorghum lines with resistance to anthracnose identified. Anthracnose is causing increasing damage to U.S. sorghum production and is difficult to combat because there are multiple biotypes of anthracnose. ARS researchers at College Station, Texas, and Mayaguez, Puerto Rico, have employed artificial inoculation methods to identify 12 sorghum accessions in the U.S. sorghum collection that are highly resistant to anthracnose. With this knowledge, researchers will be able to characterize these resistant sources in order to effectively manage the disease. In addition, the identification of these resistant lines will provide sorghum breeders with critical new germplasm for developing needed resistance to anthracnose. (NP 303, Performance Measure 3.2.4)

Genome based advances for controlling phytoplasmas and spiroplasmas. Phytoplasmas and spiroplasmas cause many agriculturally important diseases of plants, but the development of effective disease control measures is hampered by difficulties in identifying the pathogens' strains and species. ARS scientists at Beltsville, Maryland, identified candidate molecular biomarkers that can distinguish strains and species of these pathogens and that are of potential significance in the survival of the pathogens in their hosts and in the development of plant diseases. This accomplishment provides new knowledge important for understanding the mechanisms involved in pathogenicity and transmission of the pathogen by insect vectors. (NP 303, Performance Measure 3.2.3)

New virus on grapes. In collaboration with scientists from the University of California, Davis, ARS scientists at Davis, California, discovered necrotic union disorder, a viral disease, in California on the pinot noir grape on 110R rootstock. A survey of several vineyard blocks of four different pinot noir clones documented a disease incidence ranging from 5 to 45 percent, suggesting a rapid spread of the new disease. Building on this research, ARS has established a project to identify and characterize the causal agent for the disease and to study the disease development and spread and to find effective control measures for this new viral disease. (NP 303, Performance Measure 3.2.5)

Resistance to southern root-knot nematode, *Meloidogyne incognita*, discovered in wild watermelon. Root-knot nematodes cause severe damage and reduce yields in watermelon in the United States. Watermelon germplasm (USDA Plant Introductions) was evaluated by ARS scientists at Charleston, South Carolina, for resistance to southern root-knot nematode in greenhouse tests. Information on resistance and evaluation methodology was transferred to vegetable seed companies, who have begun screening watermelon germplasm, and to USDA Plant Introductions for resistance to root-knot nematodes. Discovery of resistance to southern root-knot nematode in watermelon germplasm could lead to the development of resistant watermelon varieties, which would be an important development due to the restricted availability of methyl bromide as a soil fumigant and the pending loss of other nematicides because of environmental concerns. (NP 303, Performance Measure 3.2.4)

Successful eradication of a major invasive marine weed. The invasive marine algal weed, *Caulerpa taxifolia* (Caulerpa), was eradicated from California through a cooperative interagency effort. Caulerpa had spread to over 30,000 acres in the Mediterranean Sea from 1985 to 1999, and in 2000, the first two U.S. infestations of this species were discovered in California. These infestations threatened over 600 miles of Western coastal subtidal habitat. ARS scientists at the Davis, California, worksite of the Exotic and Invasive Weed Research Unit conducted research and provided technology transfer as part of a multi-agency eradication effort during the past five years. This work was essential in the development and implementation of methods for the effective eradication of Caulerpa. This also served as a very rare example of a successful quantitative evaluation of eradication efficacy, and helped establish scientifically-based criteria for determining how and when eradication of an invasive weed could be achieved. Results have culminated in a formal declaration of eradication by the California Department of Fish and Game (July 12, 2006). The program has likely saved California millions of dollars by reducing damage and control costs and averting a potential environmental disaster. (NP 304, Performance Measure 3.2.6)

Quarantine treatment against scale insects. ARS scientists at the Pacific Basin Agricultural Research Center in Hilo, Hawaii, developed the first ever quarantine irradiation treatments for coconut scale and white peach scale, two high risk quarantine pests of banana and papaya. Research showed that an irradiation dose of 150 Gy is sufficient to provide quarantine security for both pests. The research on white peach scale provides information to lower the papaya irradiation treatment from 400 Gy to 150 Gy, which will significantly reduce treatment costs, as approximately five million pounds of papayas are currently exported from Hawaii to the U.S. mainland using irradiation. Irradiation can be an important alternative to fumigation with methyl bromide when it is effective and does not cause unacceptable phytotoxic effects. (NP 304, Performance Measure 3.2.6)

Stink bug attractant discovered. Lures are needed to monitor and manage stink bugs, including the newly invasive brown marmorated stink bug (BMSB), because these insects are immune to genetically modified crops such as cotton. Potential attractants (methyl 2,4,6-decatrienoates) were field-tested by ARS scientists in the Plant Sciences Institute at the Beltsville Agricultural Research Center in Beltsville, Maryland, resulting in the first captures of adult and nymph BMSBs, and the unexpected finding that various isomers of the tested chemicals attract certain native stink bugs. This discovery may lead to the development of lures useful in controlling stink bugs. (NP 304, Performance Measure 3.2.6)

Initiation of biological control of giant reed. ARS scientists have initiated a biological control program for the invasive weed giant reed or carrizo cane, *Arundo donax*. Giant reed is a serious ecological threat to the Rio Grande River Basin, because it displaces beneficial vegetation and uses excessive water needed to grow crops, and it also places Customs and Border Protection officers from the Department of Homeland Security at risk, because smugglers hide in dense infestations. Scientists at the Beneficial Insects Research Unit in Weslaco, Texas, have imported three potential biological control agents from Europe into USDA quarantine facilities in Texas for biological control of giant reed. These biological control agents are a shoot-feeding wasp (*Tetramesa romana*), a cane-burrowing fly (*Cryptonevra* spp.), and a rhizome-infesting scale (*Rhizaspidiotus donacis*). There is significant interest and support for the program from several U.S. and Mexico-based government organizations. (NP 304, Performance Measure 3.2.6)

Mutagenic compounds in microbial agents. Some fungi can infect many insect pests, making them useful for development as insect biological control agents. However, it is important to identify key bioactive chemistries that are present in the organism prior to use as a biological control agent. ARS scientists have recently identified two compounds of a *Fusarium* species as mutagenic. While the relevance of this is currently unknown, it heightens the need to develop a more complete understanding of these products. (NP 304, Performance Measure 3.2.5)

*Integrated control of redvine and trumpetcreeper in glyphosate resistant soybean. Redvine, *Brunnichia ovata*, and trumpetcreeper, *Campsis radican*, are perennial, deep rooted vines found extensively in crop and noncrop lands in the Lower Mississippi Delta region. Glyphosate alone cannot provide complete control of these weeds, so additional management tactics are needed that are affordable and sustainable. Scientists at the Southern Weed Science Research Unit in Stoneville, Mississippi, completed a 4-year field study to determine the effectiveness of fall deep tillage and glyphosate on redvine and trumpetcreeper populations and soybean yield. Fall deep tillage (about 18 inches) reduced redvine density compared with shallow tillage (about 6 inches), but deep tillage did not reduce trumpetcreeper density; soybean yields were higher with deep tillage. Glyphosate applied before planting and after crop emergence reduced trumpetcreeper density, but not redvine density. These results demonstrate that integration of fall deep tillage and glyphosate applications could be an effective strategy to manage these vines in glyphosate resistant soybean. (NP 304, Performance Measure 3.2.6)

Corn rootworm infestations in Europe coming from multiple introductions from North America. The Western corn rootworm is the most destructive pest of corn in the United States and is now in several European countries after first being detected near Belgrade in 1992. ARS scientists using DNA markers were able to show that the species is invading Europe not only by spreading from the original introduction but also through repeated new introductions from North America. These results show the role of transoceanic transport of harmful pest species and indicate that more attention should be paid to controlling pests on intercontinental flights. (NP 304, Performance Measure 3.2.6)

Tropical spiderwort can eliminate peanut yield. Tropical spiderwort, *Commelina benghalensis*, an exotic invasive weed, has quickly spread in the Southeast Coastal Plain and is the second most troublesome weed in peanut crops. Researchers from the ARS Crop Protection and Management Research Unit in Tifton and Dawson, Georgia, cooperated with University of Georgia scientists to conduct field studies to determine the length of time that peanut fields need to be kept free of tropical spiderwort to minimize yield losses. Research demonstrated that tropical spiderwort was capable of causing 100 percent peanut yield loss after just six weeks of competition. Peanut yield loss was less than 10 percent when plots were kept free of spiderwort for 3- to 6-weeks after peanut planting. This critical period of weed control coincided with peak spiderwort emergence. Growers will use this information to implement a strategy that eliminates spiderwort competition during this interval, saving considerable resources. (NP 304, Performance Measure 3.2.6)

Goal 5: Improve the Nation's Nutrition and Health

Human Nutrition

Adherence to the 2005 Dietary Guidelines lowers risk for cardiovascular disease. USDA and HHS share responsibility for revising the Dietary Guidelines for Americans every five years. In the Framingham Heart Offspring cohort study, ARS scientists in Boston, Massachusetts, found a 50 percent lower prevalence of metabolic syndrome in men and women who adhered strictly to the Dietary Guidelines. Metabolic syndrome, characterized by abdominal obesity and the inability to use insulin efficiently, is a forerunner of type 2 diabetes and increases risk for coronary heart disease. (NP 107, Performance Measures 4.1.1, 4.1.2 and 4.1.3)

Many Americans receive inadequate amounts of vitamins A, C, and E. Using data from the "What We Eat in America/NHANES 2001-2002" national dietary survey, ARS scientists in Beltsville, Maryland, found a high prevalence of vitamins A, E, and C deficiencies among most age and gender groups in the U.S. This is the only source of nationally representative dietary intake data and is essential to tracking the health and well-being of the American population. (NP 107, Performance Measure 4.1.3)

Excess folic acid problems. Folic acid fortification is mandated by Federal law to help prevent certain birth defects. ARS scientists in Boston, Massachusetts, found that 4 of 5 postmenopausal women have unmetabolized (indicating excess) folic acid in their blood. This was correlated with impaired functioning of part of the immune system. This observation illustrates the importance of continuously monitoring the food supply along with benefits and risks of nutrient intake. (NP 107, Performance Measure 4.1.1 and 4.1.2)

Beneficial role of vitamin D and calcium in reducing the risk for type 2 diabetes. The prevalence of type 2 diabetes has increased rapidly in the U.S. and worldwide. ARS scientists in Boston, Massachusetts, found that women with a combined daily intake meeting the Recommended Dietary Intakes for both calcium and vitamin D had a 33 percent lower risk of developing type 2 diabetes than those with lower intake levels. The findings from this study, which followed nearly 84,000 women for 20 years, suggest a possible dietary strategy for lowering the risk for type 2 diabetes. (NP 107, Performance Measure 4.1.2)

Adequate postmenopausal bone density dependent upon calcium intake during the early menopausal years. ARS scientists in Davis, California, demonstrated that calcium intake during the early menopausal years is more important for maintaining adequate bone density than calcium intake during childhood years, in contrast to previously published reports. Dietary strategies to alleviating postmenopausal bone mineral loss help lower health care costs and improve the quality of life for American women. (NP 107, Performance Measure 4.1.2)

Carbohydrate calories contribute to body fat. ARS scientists in Little Rock, Arkansas, showed that overconsumption of carbohydrates produced significant weight gain and fat deposition in both human infants and a mouse model. In a related study, ARS scientists in Boston, Massachusetts, found that obese adults on a weight loss diet providing a low glycemic index (carbohydrates that raise blood sugar slightly) experience greater weight loss over one year than volunteers on a weight loss diet providing a high glycemic index. These studies will help refine dietary recommendations for maintenance of healthy weight. (NP 107, Performance Measure 4.1.1)

Fish fatty acids prevent dementia. Analysis of blood from elderly men and women revealed that those with the highest levels of omega-3 fatty acids from fish were half as likely to develop dementia, including Alzheimer's disease. ARS scientists in Boston, Massachusetts, studying a group of 900 people, found that eating more than two servings of fish weekly was associated with maintenance of normal brain function over nine years of follow-up. This study contributes to solving the controversy about the quantity of omega-3 fats required for optimal health. (NP 107, Performance Measure 4.1.2)

Cherries cut inflammation. Healthy adult volunteers who ate large amounts of sweet cherries for 28 days had significant reductions in several blood markers of inflammation. ARS scientists at Davis, California, suggest these reductions lower risk for inflammatory diseases such as arthritis and cardiovascular disease. (NP 107, Performance Measure 4.1.2)

Cinnamon lowers blood pressure. ARS scientists previously found that consumption of cinnamon lowers blood sugar levels in diabetics. This year, ARS scientists in Beltsville, Maryland, showed that feeding large amounts of cinnamon to rats with hereditary hypertension reduced blood pressure to normal. This observation has potential for preventing or treating high blood pressure in humans. (NP 107, Performance Measure 4.1.2)

Air displacement instrument accurately measures infant body fat. ARS scientists in Houston, Texas, verified the accuracy of an air displacement instrument (Pea Pod) for the measurement of body fatness in infants. Now, longitudinal body composition monitoring of infants during their first six months of life can be performed accurately and without risk to the infant. In turn, this information can be used to better understand the healthfulness of early life feeding regimes. (NP 107, Performance Measure 4.1.2)

Goal 6: Protect and Enhance the Nation's Natural Resource Base and Environment

Environmental Stewardship

Mapping seasonal and spatial variability of dry periods between storms in the Great Plains. ARS scientists in Coshocton, Ohio, have developed a storm generation model that simulates storm occurrence, duration, and precipitation intensities within the rainfall event. The storm model can be used with watershed models to show how various agricultural practices impact surface and subsurface water movement in areas where there are no precipitation records. A "critical duration" (CD) parameter for characterizing minimum dry times between storms was mapped over a 225,000-square kilometer area covering parts of Wyoming, Colorado, Nebraska, and Kansas. The monthly mapped CD values provide the most accurate estimates of CD, which is highly variable from month to month and from location to location. The CD is required for use in the storm model for ungauged areas, and for further precipitation data analysis. The results of this study have been used to more completely quantify times between storms. Enhanced storm model development will result in improved ground water and runoff modeling, better peak flood flow estimates, improved drought characterization, and better erosion control designs by Federal and State agencies, university scientists, and private consultants. (NP 201, Performance Measure 5.2.1)

Tiny creatures help to measure water quality. *Hyalella azteca* (crustaceans) can be a fast and inexpensive biological indicator of good quality water. The 1/8-to-1/4 inch long crustaceans are commonly found in lakes, ponds, and streams throughout North America. Using chemical and physical measures to monitor water quality reveals the effects of improved conservation farming practices. However, using *Hyalella* as a biological indicator will confirm whether these practices have actually improved the overall health of the ecosystem for fishing or swimming. (NP 201, Performance Measure 5.2.1)

Grass hedges catch runaway soil. Narrow, parallel rows of stiff stemmed grass, planted along the contour of steep hills, can successfully halt soil erosion caused by flowing water. ARS scientists at the National Sedimentation Laboratory in Oxford, Mississippi, and the Plant Science and Water Conservation Research Laboratory in Stillwater, Oklahoma, compared two types of stiff grass hedges—Switchgrass and Eastern Gamagrass-- in field and flume facilities. Switchgrass proved better adapted to flooding than Gamagrass. Switchgrass held back sediment and water until the water ponded upstream to a depth of 1.4 to 1.6 feet. Switchgrass also showed a better recovery response from flooding in the previous year; it can also be mowed and used in the development of biofuels. (NP 201, Performance Measure 5.2.1)

Management strategies for reducing fertilizer loss from golf courses. Large quantities of fertilizer are used to maintain turfgrass on golf courses, but protecting water quality in turfgrass environments has been hampered by a lack of models or decision support systems sensitive to enhanced turfgrass management practices. Quantitative data of surface water nutrient loads from turfgrass systems were collected, and the Agricultural Land Management Alternatives with Numerical Assessment Criteria (ALMANAC) model, which was developed by ARS scientists in Temple, Texas, was modified to evaluate turfgrass fertilization strategies. This model provides a new tool for assessing turfgrass fertilization on a range of scales, from a single golf course to an entire watershed, and has been adopted and used by the turfgrass industry. (NP 201, Performance Measure 5.2.1)

Drainage ditches improve surface water quality. Drainage ditches are a common feature in agricultural landscapes. ARS researchers at Oxford, Mississippi; West Lafayette, Indiana; and University Park, Pennsylvania, are evaluating the efficiency of properly-managed ditches in keeping agricultural runoff containing pesticides from polluting nearby water bodies. They found that ditches can trap 60 to 90 percent of commonly-used herbicides and insecticides carried in runoff water, and therefore appear to be a simple, low-tech, inexpensive way to improve water quality when properly managed. (NP 201, Performance Measure 5.2.1)

Locating old tile lines enables better drainage management. In cooperation with Ohio State University, ARS scientists at the Soil Drainage Research Unit in Columbus, Ohio, have successfully modified ground-penetrating radar equipment to locate operational and non-operational tile lines. Extensive studies at thirteen sites throughout Ohio showed that this method located an average of 72 percent of the old buried tile lines. Current estimates suggest this detection method will save farmers and land improvement contractors about $10 million annually throughout the United States and will be an effective way to mitigate agricultural runoff that contributes to the Gulf of Mexico's nutrient loading. (NP 201, Performance Measure 5.2.1)

An improved nitrogen management tool has been developed. Improved nitrogen management tools are needed to make more efficient use of nitrogen fertilizers and to prevent movement of fertilizer and manure nitrogen to water and air. ARS scientists from Fort Collins, Colorado, and their cooperators have developed an updated version of the USDA nitrogen computer simulation model, the Nitrogen Loss and Environmental Assessment Package (NLEAP). The model can predict nitrogen form, application rate, timing, and application alternatives for different cropping systems and conditions. The model has been transferred to the Natural Resources Conservation Service where it will be used in the selection of appropriate management practices for increasing nitrogen use-efficiency in crops and reducing nitrogen losses to water and air. (NP 202, Performance Measure 5.2.2)

Site-specific in-row subsoiling saves fuel. Many soils in the United States suffer from excessive soil compaction and have to be tilled annually to eliminate deep compacted layers. New spatial technologies may reduce fuel consumption while producing optimum yields. ARS scientists from Auburn, Alabama, conducted a four-year experiment to compare the impact of site-specific subsoiling and uniform deep subsoiling on corn yield and tillage energy requirements. Prior to in-row subsoiling the soils were mapped to determine the depth of the compacted layer; this information was used to supply site-specific subsoiling treatment tillage to the appropriate depth. The site-specific subsoiling treatment reduced fuel requirements from 24 percent to 43 percent, and resulted in the same corn yields as uniform deep subsoiling. Site-specific subsoiling can increase producer profits by reducing fuel costs while maintaining crop yields. (NP 202, Performance 5.2.2)

Root colonizing mycorrhizal fungi can enhance nitrogen uptake by plants. Mycorrhizal fungi found in soil can colonize plant roots and form a symbiotic relationship that can enhance crop uptake of nutrients. ARS scientists from Wyndmoor, Pennslyvania, and cooperators from New Mexico State University and Michigan State University found that mycorrhizal fungi outside of the root can take up many forms of nitrogen, convert them into amino acids, and transport the amino acids to the root where nitrogen is released and taken up by the plant. The fungi can provide a significant amount of the nitrogen used by the host plant. Successful establishment of the mycorrhizal fungi – host plant symbiosis will facilitate more efficient use of applied nitrogen and will result in lower fertilizer application rates, thus saving energy and protecting the environment. (NP 202, Performance Measure 5.2.2)

Development of a model to predict soil carbon sequestration. Tools are needed to predict changes in soil carbon storage in agricultural systems. ARS scientists at Pendleton, Oregon, and Fort Collins, Colorado, have developed a carbon sequestration model (CQESTR) to predict the effect of cropping systems, management practices, climate, and soil conditions on carbon storage in agricultural soils. The model has been delivered to the Natural Resources Conservation Service (NRCS) for beta testing and evaluation. CQESTR will help advisors and land managers in predicting field scale carbon sequestration to assess soil quality improvements and to provide information for soil carbon credit trading. (NP 202, Performance Measure 5.2.2)

New technology for rapid measurement of soil properties. Site specific management of agricultural landscapes requires new technologies for measuring soil properties in time and space. ARS scientists from Beltsville, Maryland, demonstrated that diffuse reflectance infrared spectroscopy (DRIS) can be used to measure soil carbon content and soil composition regardless of mineralogy, carbon composition, or carbon content. The method has been demonstrated on a wide variety of soils, including tropical soils from Brazil. This technique is also useful for

identifying other soil fertility parameters and soil metals. The method will permit rapid spatial mapping of soil properties for site specific management and will provide a rapid measurement of soil carbon to help expedite carbon credit trading. (NP 202, Performance Measure 5.2.2)

Impact of soil conditions on herbicide degradation. Many of the processes affecting the behavior of herbicides in the environment are mediated by microorganisms, but there is limited information about the impact of environmental conditions or management practices on the microbial degradation of herbicides. ARS scientists from Urbana, Illinois, found that soil nitrogen controls the microbial degradation of herbicides. Soil nitrogen levels required for crop production are not conducive for the degradation of herbicides such as atrazine and cloransulam-methyl. These herbicides undergo optimal degradation when the microbial community is starved for nitrogen. ARS scientists, in cooperation with personnel from the University of Illinois and the U.S. Army Corps of Engineers, found that under anaerobic conditions, organisms that degrade explosives also can degrade herbicides called dinitroanilines. This information can be used to predict the persistence of herbicides in soil and to develop management practices to reduce herbicide persistence. (NP 202, Performance Measure 5.2.2)

Remote sensing of soil surfaces to identify locations affected by rainfall and wind erosion. Researchers need to be able to distinguish between regions that have been modified by rainfall and regions that have been disturbed by wind erosion. ARS scientists at the Wind Erosion and Water Conservation Research Unit at the Cropping Systems Research Laboratory in Lubbock, Texas, measured light wavelengths reflected from three soils that had been modified by artificial rainfall and then abraded with sand in a wind tunnel. Wavelength reflectance analysis was used to successfully identify the difference in soil texture (relative amount of sand, silt, and clay particles in the soil), the occurrence of a soil crust created by the artificial rainfall, and the presence of loose sand on the crust surface that could easily be blown away by wind. The results have the potential for improving understanding of soil properties, and identifying and measuring erosion on a global scale. (NP 202, Performance Measure 5.2.2)

Conservation tillage benefits in semi-arid regions. Sandy soils in semi-arid regions are susceptible to wind erosion and reduced soil quality as a result of agricultural operations. ARS scientists at Lubbock, Texas, measured the impact of conservation tillage, conventional tillage, conservation grassland, and native rangeland on soil properties considered important for crop production, including soil aggregation and soil organic carbon. They found that long-term conservation tillage management provided more favorable soil chemical, biological, and physical properties for ecosystem functioning than conventionally tilled systems. The study showed that conservation tillage in the Texas High Plains was as beneficial to soils as placing the soils in a grassland reserve. This information could help conservation planners suggest the appropriate USDA Conservation Program—either the Conservation Security Program or the Conservation Security Program--for producer participation. (NP 202, Performance Measure 5.2.2)

New technology improves measurement accuracy for agricultural aerosols. Research has shown that devices for sampling aerosols over-sample agricultural particulate matter, thus biasing measurements that may be used by regulatory agencies. ARS scientists at the Cropping Systems Research Laboratory in Lubbock, Texas, working cooperatively with the USDA Cotton Production and Processing Research Unit in Lubbock, Texas, the USDA Southwestern Cotton Ginning Research Laboratory at Mesilla Park, New Mexico, and the Center for Agricultural Air Quality Engineering and Science at Texas A&M University, developed a new sampling head that reduces errors and provides a more accurate particulate matter concentration measurement. The device enables better measurement and monitoring of particulate matter from agricultural sources and will contribute to efforts to assure that agricultural industries are equally regulated. (NP 203, Performance Measure 5.2.3)

Diffusion model study suggests more efficient herbicide application strategy. Pesticide movement in soils is affected by pesticide application methods, soil and environmental conditions, and water management practices. Soil diffusion models provide a method for studying pesticide fate and transport under varying management practices and environmental conditions, thus offering an additional tool for developing new application strategies. ARS scientists at the U.S. Salinity Laboratory in Riverside, California, used a new soil diffusion model that had been validated with simulated and measured values to show that surface application of triallate would lead to emissions of 80 percent and a soil concentration of 6 percent after 100 days, Alternatively, incorporating triallate to a depth of 10 cm in the soil would reduce emissions to less than 5 percent and result in a soil concentration of 41 percent after 100 days. The results suggest that different approaches to pesticide application may improve application efficiency and reduce environmental contamination. (NP203, Performance Measure 5.2.3)

Soil particles contribute to atmospheric concentration of herbicides in Chesapeake Bay rural areas. Information on the fate and transport of agrochemicals in both vapor and particle phases is needed to mitigate agrochemical deposition on surrounding ecosystems. During spring and summer, the cultivation of surface soils leads to an increased release of coarse particulates into the atmosphere. Research by the Environmental Management and By-Product Utilization Laboratory in Beltsville, Maryland, determined that particle pesticide concentrations were much greater than estimates generated by standard vapor-particle partition models based on the physical properties of the pesticides. Field tilling, or even moving planting and spraying equipment through the field prior to and during pesticide application, results in the suspension of soil particles containing old pesticide residues applied during previous years, as well as residues from recent applications. The results provide information about pesticide fates and transport needed for development of improved agricultural practices to reduce pesticide movement into surrounding ecosystems. (NP 203, Performance Measure 5.2.2)

Refining methods to identify sources of soils contributing to environmental degradation. Efforts to improve land-use practices to prevent air and surface water contamination from soil sediment are limited by their capacity to identify the primary sources of eroded sediment. ARS scientists at the Land Management Water Conservation Research Unit at Pullman, Washington, determined that fatty acid methyl ester (FAME) analysis was more useful for identifying the source of wind-eroded soil than other soil community analyses. Recent research has confirmed that the season during which soil is collected determines the success of identifying the source of eroded sediment. This research provides further confirmation that FAME analysis holds promise for identifying the primary source of sediment in air and surface waters, and may be an important tool for the identification of areas most vulnerable to erosion, as well as for the validation of wind erosion models. (NP 203, Performance Measure 5.2.2)

Market-based carbon trading based on GRACEnet results. Credible and regionally relevant data documenting agroecosystem effects on soil carbon storage are needed for successful implementation of market-based carbon trading programs. ARS scientists from 29 locations across the United States are conducting a coordinated project called Greenhouse gas Reduction through Agricultural Carbon Enhancement network (GRACEnet) to provide information on soil carbon status and greenhouse gas emission associated with current agricultural practices. Information from a recent GRACEnet review article was used in the development of a carbon credit program for the North Dakota Farmers Union (NDFU) in collaboration with the Chicago Climate Exchange. Producers participating in the program, which included continuous conservation tillage (no-till) and seeded grassland, are credited with 0.4 metric tons carbon dioxide/acre/year for no-till and 0.75 metric tons carbon dioxide/acre/year for seeded grass over the duration of a five year contract; about 830,000 acres were enrolled during the 2006 sign-up period. The NDFU carbon credit program has the potential to realize multiple benefits for agricultural producers, including increased farm income and improvements in soil quality, while concurrently mitigating agriculture's impact on global climate change. (NP 204, Performance Measure 5.2.4)

Wheat crop response to interacting effects of water stress, nitrogen deficiency and increased atmospheric carbon dioxide. Increased atmospheric carbon dioxide concentration has been shown to enhance carbon supply in the above ground (shoot) plant components of wheat. However, the interaction of the effects of water stress and nitrogen under elevated carbon dioxide conditions are unknown. Research by ARS scientists at the U.S. Arid Land Agricultural Research Center in Maricopa, Arizona, showed that elevated carbon dioxide and ample water and nitrogen (N) increased root and shoot mass by 18 percent and 16 percent, respectively. Under drought conditions, elevated atmospheric carbon dioxide caused an increase of root exploration into deeper soil layers, whereas under N deficits it increased root growth in the upper soil layers. These results will enhance our ability to adapt wheat crop production management to increasing atmospheric carbon dioxide by better managing water and N resources. (NP 204, Performance Measure 5.2.4)

Spread of invasive species associated with wildfires may be linked to increasing atmospheric carbon dioxide. Plant response to rising atmospheric carbon dioxide may result in greater competition between crops and weeds commonly encountered in production crops, as well as an increase in the spread of invasive species in uncultivated landscapes. Research by ARS scientists from the Crop Systems and Global Change Laboratory in Beltsville, Maryland, indicates that the growth and combustability of cheatgrass, an invasive species associated with fire outbreaks in the Western United States, may be related to increases of atmospheric carbon dioxide during the 20th century. The study indicates that, in addition to changing precipitation and temperature patterns, changes in atmospheric carbon dioxide may be a factor in the spread of invasive species. (NP 204, Performance Measure 5.2.4)

ARS global change research in range and pasture lands summarized. Concerns about global change have centered on the rapid increase in atmospheric concentrations of primary greenhouse gases carbon dioxide, methane and nitrous oxide. A state-of-the-state report on global change in rangelands and pasturelands identifies three significant advances in understanding how plants and soil respond to increasing atmospheric carbon dioxide, as well as how land management practices can mitigate global change: 1) elevated carbon dioxide levels can significantly impact rangeland plant community dynamics, increase water use efficiency and reduce nitrogen content of the plant material; 2) land management practices--such as grazing, fertilization, fire, and introduction of legumes and improved grass species--can increase soil organic carbon storage in rangelands and pasturelands; and 3) the development of non-interference methods may be effective for monitoring methane emissions from isolated animals in large feedlots. (NP 204, Performance Measure 5.2.4)

Nitrous oxide emissions from corn and soybean crops may be underestimated. Measuring the exchange of greenhouse gases such as nitrous oxide between the soil and atmosphere is key to assessing the effects of farming practices on global climate. ARS scientists from the Air Quality and Agricultural Systems Research Laboratory in Ames, Iowa, measured nitrous oxide emissions from corn-soybean systems with full width tillage, no-till, and no-till with rye winter cover crop for two years. No significant tillage or cover crop effects on nitrous oxide emission were observed. However, comparing the actual measurements with estimates calculated using the Intergovernmental Panel on Climate Change default emission factor indicated that the estimated fluxes underestimate the measured emissions at the Iowa sites by a factor of three. The research indicates that worldwide assessments of nitrous oxide greenhouse gas emissions may seriously underestimate the actual emissions amounts, and that a reassessment of the impact of nitrous oxides from agriculture on global climate is needed. (NP 204, Performance Measure 5.2.4)

Screening soybean ancestors for potential sources of ozone tolerant genes. Ground-level ozone concentrations are sufficient to suppress crop yields in many agricultural areas and may increase to the point where crops such as soybeans may suffer significant yield losses. Thirty soybean ancestors representing a majority of genes in modern U.S. cultivars were screened for ozone sensitivity under greenhouse conditions by scientists of the ARS Plant Science Research Unit and the ARS Soybean and Nitrogen Fixation Research Unit in Raleigh, North Carolina. Two ancestors exhibited minimal ozone injury following a 5-day exposure to elevated ozone levels. If confirmed in yield tests, these ozone-tolerant ancestors represent sources of genes for development of new ozone tolerant cultivars that could maintain current levels of productivity under future climate scenarios where ambient ozone concentration are expected to be much higher than current levels. (NP 204, Performance Measure 5.2.4)

New wheat-grazing model for assessing productivity impacts of climate forecasts. Climate variations can greatly affect the productivity of winter wheat-grazing operations of the Southern Great Plains. A climate impact assessment tool is needed to evaluate planning and management alternatives in terms of forecasted climate conditions. A new grazing-cattle growth model was developed and incorporated into a commercial wheat production model for this purpose. Use of the wheat production and grazing model provides the means to plan and manage wheat-grazing systems under anticipated climate variations and forecasts and will help producers adapt to changing global climate conditions. (NP 204, Performance Measure 5.2.4)

Economic feasibility of growing Switchgrass for bioenergy. On-farm trials are required to determine the economic feasibility of producing Switchgrass as a bioenergy crop in the Eastern Great Plains so the Nation can accurately assess the feasibility of this energy option. ARS scientists at Lincoln, Nebraska, in cooperation with the University of Nebraska, managed and assessed Switchgrass production for 5 years on 10 farms in Nebraska, North Dakota, and South Dakota. Average Switchgrass yield was 3.4 tons/acre with average production cost of $33/ton, plus $17/ton for land rent. Prorating the establishment costs over nine years would reduce costs by $6/ton. Two farmers experienced in Switchgrass production were able to produce the biomass for less than $40/ton, including land costs. Given these costs, the farm-gate feedstock cost per gallon of ethanol produced would be about $0.50 per gallon. These results suggest that Switchgrass is an economically-feasible biofuel crop for agricultural producers, and that its overall economic viability as a biofuel depends on transportation costs to the processing plant and subsequent conversion costs. (NP 205, Performance Measure 5.1.1)

Halting rangeland degradation from cheatgrass. Cheatgrass, which has spread across millions of acres of western rangelands, is currently one of the most invasive weeds affecting these rangelands. In just one year in Nevada, over $80 million was spent fighting wildfires and restoring critical areas damaged by cheatgrass; even more losses were incurred from degraded soil and water resources, burned forages unavailable to wildlife and livestock, and overall

ecosystem damage. Botanists used to believe that cheatgrass was self-pollinating and limited in its ability to adapt to changing conditions, such as changes in range management practices. ARS scientists at Reno, Nevada applied molecular genetics techniques to characterize cheatgrass populations and documented that cheatgrass does out-cross to some extent. This cross-pollination between plants results in increased genetic diversity that allows cheatgrass to adapt to new environments more quickly. This discovery may complicate future attempts at controlling cheatgrass but the out-crossing between plants may open up new lines of controls based on genomic manipulation. This information will let scientists and land managers develop methods of controlling cheatgrass more effectively by applying limited funds to the most promising avenues of control. (NP 205, Performance Measure 5.1.1)

Improving revegetation success on degraded rangelands. Wildfires, droughts, and other agents of ecosystem degradation strip the land of vegetation essential for protecting watersheds, providing wildlife habitat, feeding livestock, and enhancing recreational activities. Following degradation, managers need affordable seeds from native vegetation that have a high probability of successful establishment and that will conserve biodiversity. ARS scientists at Logan, Utah, have released a new variety of Slender Wheatgrass, a key restoration species, called FirstStrike. In field trials in Idaho, Utah, and Wyoming, FirstStrike proved to be equal to or superior to other commercial varieties in seedling establishment, number of seedlings per unit area, initial stand and persistence, and dry matter yield. FirstStrike has been adapted by 42 Department of Defense facilities encompassing 1.3 million acres of land regularly reseeded following training exercises. (NP 205, Performance Measure 5.1.1)

Release of new Italian Ryegrass, Floregon. Extending the length of the grazing season significantly increases the profitability of the livestock industry because it reduces the need to feed livestock with hay and other harvested forages. A key factor in determining the length of the grazing season is how quickly forage plants shift from vegetative growth to seed production, when both the quality and quantity of forages drops. ARS scientists at Corvallis, Oregon, working with the University of Florida, have released a new cultivar of Italian Ryegrass called Floregon, an important winter pasture grass in the Southeast. The new cultivar meets the needs of the Oregon seed industry with robust seed production, as well as the needs of Southeastern livestock producers, who want a longer grazing season. An estimated two million pounds of seed will be available for market at the end of the 2007 growing season. (NP 205, Performance Measure 5.1.1)

Controlling Broom Snakeweed to protect ecosystem and animal health. Broom Snakeweed is a native invasive plant that chokes out more desirable vegetation, degrades wildlife habitat, and may cause abortions in cows, sheep and goats. Scientists at Logan, Utah, studied how grazing affected sagebrush plant communities experiencing invasion from Snakeweed. After many years of spring grazing, degradation resulted in dense Wyoming big sagebrush stands, with sandberg bluegrass understory and some Snakeweed. Fall grazing every other year maintained a plant community characterized by a healthy mix of perennial bunchgrass and intermittent big sagebrush that crowded out Snakeweed over a four-year study period. Fire on the spring grazing site knocked out the sagebrush, which allowed Snakeweed to dominate the site. However, fire did not create significant impacts on the fall grazing site. This information provides ranchers and public land managers with grazing management tools to improve rangeland health and protect livestock from abortions caused by a toxic weed. (NP 205, Performance Measure 5.1.1)

Increased seed production for bioenergy and forage. Eastern gamagrass is a highly productive and digestible native grass with significant potential in livestock and bioenergy production. However, utilizing the potential offered by Eastern gamagrass could be limited by its seed availability. ARS scientists at Woodward, Oklahoma, applied high-throughput molecular genetics techniques to speed the selection of seed production traits. They found a mutant form of gamagrass that only produces female flowers, as opposed to the predominately male type found in the wild. Identifying the mutant form caused by recessive genes and identifying suitable plants to cross will allow scientists to develop gamagrass varieties that will greatly increase seed production, which will provide another option for improving livestock and bioenergy production. (NP 205, Performance Measure 5.1.1)

Documentation of ammonia emissions from beef cattle feedlots. Ammonia emitted from beef cattle feedlots represents a loss of manure nitrogen fertilizer value and can negatively impact the local and regional environment. ARS scientists from Bushland, Texas and Watkinsville, Georgia, along with cooperators from Texas A&M University, West Texas A&M University, and the University of Alberta, used four micrometeorology and nutrient balance methods to measure ammonia emissions from a 50,000-head feedlot. All four methods resulted in similar ammonia emission measurements of 44 to 60 percent of fed nitrogen during the summer, and 15 to 40 percent of fed nitrogen during the winter. On an annual basis, ammonia emissions from the feedlot averaged 31.7 pounds per head

capacity, with 48 percent of fed nitrogen lost as ammonia. This multi-year study provides the most comprehensive and current measurement of ammonia emissions from a beef cattle feedlot. This information can be used in the development of policy and regulatory decisions, and will contribute to the development of a process model for ammonia emissions. (NP 206, Performance Measure 5.2.5)

Measurement and control of pathogens. Water and foodborne pathogens can pose a significant threat to human health, as illustrated by the recent problems associated with *E. coli* O157:H7 contamination of spinach. Methods are needed to detect *E. coli* O157:H7 in a variety of matrices and to minimize its survival and transport in the environment. ARS scientists from Riverside, California, have developed a methodology that allows them to quantify *E. coli* O157:H7 at levels less than 100 cells per gram of soil, manure, or water. This method was used to demonstrate that *E. coli* O157:H7 can survive at least 45 days in soil even if the moisture content is as low as three percent. This information suggests that aggressive methods will be needed to control pathogens in the environment. Scientists from Mississippi State, Mississippi have identified and collected viruses called bacteriophages from swine lagoons. These bacteriophages kill *Salmonella*, a pathogen that can infect humans and animals. Additional research is needed to refine this approach to help control or eliminate movement of pathogenic bacteria from animal production operations. (NP 206, Performance Measure 5.2.5)

Swine wastewater treatment systems reduce greenhouse gas emissions. Substantial greenhouse gas (GHG) emission reductions in confined swine operations can result when anaerobic swine lagoons are replaced with advanced technologies that use aerobic treatment. A swine wastewater treatment technology developed by ARS scientists in Florence, South Carolina and industry cooperators reduces or eliminates ammonia emissions, nutrient losses, odors, and pathogens. In addition, this system is more effective than anaerobic lagoons and anaerobic digesters reducing GHG emissions. Replacing an anaerobic lagoon at a 4,360-head swine operation with the new treatment technology reduced GHG emissions from 4,972 tons of carbon dioxide equivalents per year to 50 tons of carbon dioxide equivalents per year. This GHG reduction translates into a direct economic benefit to the producer of approximately $4.50 per pig capacity per year at a Chicago Climate Exchange trading value of $4 per ton of carbon dioxide equivalent emissions reduction. GHG emission reduction credits can compensate for the higher installation cost of new aerobic treatment systems and will encourage producers to replace anaerobic lagoons with environmentally superior technologies. (NP 206, Performance Measure 5.2.5)

Low-cost restoration of degraded lands. Soils degraded by human activities and natural processes cannot effectively support crop production or vegetative cover, require greater inputs to establish and maintain plant production, and pose a threat to the environment. The U.S. Army has significant land areas that require remediation due to physical, chemical, and biological soil constraints resulting from military training activities. ARS scientists from Auburn, Alabama, are working with the U.S. Army Corp of Engineers to remediate degraded sites at Fort Campbell, Kentucky, and Fort Benning, Georgia, using an “aggregate cellulose pulp” made from solid waste generated at military bases. The pulp byproduct has improved soil conditions and resulted in enhanced plant growth. Beneficial use of this material will reduce disposal costs at Army bases by $100 million per year and will provide environmental benefits through remediation of military lands. (NP 206, Performance Measure 5.2.5)

Fate and transport of natural and synthetic hormones. Natural and synthetic hormones are given to and generated by livestock and poultry. Scientists, policy-makers and producers require information to determine if hormones pose environmental and human health risks when manures are applied to agricultural land. Scientists from Watkinsville, Georgia, tracked leaching of estradiol and testosterone, two natural hormones produced by poultry, through the soil. They found 27 percent of estradiol and 42 percent of testosterone leached through soil, probably as a result of water movement through worm holes, large interconnected soil pores, and cracks in the soil column. Since hormones appear to be mobile, methods are needed to degrade these compounds. One promising line of research has been initiated by ARS scientists from Fargo, North Dakota, and Florence, South Carolina. They found that “green catalysts” known as TAML activators (iron tetra-amido macrocyclic ligand) were very effective destroying hormones. Further work will be needed to determine if these catalysts can destroy hormones in a variety of environmental matrices. (NP 206, Performance Measure 5.2.5)

Rapid method to determine phosphorus in animal manure. Rapid methods for assessing phosphorus levels in manure are needed by producers and their advisors to determine appropriate manure application rates. ARS scientists from Beltsville, Maryland, have developed a robust x-ray fluorescence method to measure phosphorus non-destructively in cattle manure, poultry litter, and feed samples in varying physical states and composition. The x-ray fluorescence

method can detect how different handling and storage conditions affect the composition of manure and the subsequent mineralization and release of phosphorus. This spectrometric method will eventually be transportable to the field for on-site analysis of phosphorus and other minerals in manures. On-farm phosphorus analysis will greatly improve nutrient management by allowing producers and their advisors to determine application rates based on the actual composition of the manure. (NP 206, Performance Measure 5.2.5)

Helping farmers economically transition from conventional to conservation tillage systems. Many producers who are using conventional tillage systems mistakenly think that they must suffer several years of reduced crop yields prior to their soils responding positively to a reduced tillage system. The first phase of a large 20-acre long-term field experiment was completed by ARS scientists at Auburn, Alabama, and Watkinsville, Georgia, to determine the impacts of transitioning from a conventional tillage to a conservation tillage system. This experiment was the first in the region to examine interactions among crop management systems, productivity, and landscape positions using soil survey, topography, and electrical conductivity maps to define management zones. Results indicated that in every kind of field management, the use of conservation systems resulted in immediate increased crop productivity – 14 percent on average for cotton when compared to the conventional tillage systems. The results of this experiment indicate that producers who farm Coastal Plain soils can immediately begin to take advantage of increased yields when converting their row crop production system from conventional tillage to conservation tillage.
(NP 207, Performance Measure 5.2.6)

Field management practices that increase agriculture profitability. There are approximately 23,000 small farms in New England that require optimal combinations of rotation crops and conservation practices to achieve maximum profitability. The right combination of practices brings growers additional income and can be an effective method to suppress potato diseases, enhance soil nutrient content, and boost crop productivity and quality while reducing the use of agricultural chemicals. An interdisciplinary team of ARS scientists at Orono, Maine, used soil, plant disease, crop productivity, and economic research approaches to develop potato crop rotations that increase farm profits. Incorporating canola into the rotation reduced *Rhizoctonia*, common scab, and Powdery Scab diseases by 20 to 50 percent, thereby increasing both potato yield and quality, and reducing the chances of economic loss from 37 to 15 percent when compared to a monoculture potato rotation. Controlling the common weed Hairy Nightshade reduces a source of the fungus that causes Late Blight. Using ryegrass cover crops not only reduces soil erosion during the winter, but also helps reduce *Rhizoctonia*. The introduction of raised planting beds seeded with green sprouted potatoes consistently increased net income $40 per acre. An economics calculator tool, based on the same input as required for loan applications by the USDA Farm Service Agency, helped growers estimate the profitability of each cropping system. Since 2005, over 750 copies of the *Potato Systems Planner* have been distributed to growers and scientists in 21 States, 7 Canadian provinces, and 8 countries. (NP 207, Performance Measure 5.2.6)

Western Oregon farm landscapes can provide excellent fish and wildlife habitat. Aquatic and terrestrial habitats on farmland can protect many fish and wildlife species during crop production. ARS scientists at Corvallis, Oregon, cooperating with Oregon State University and the University of Massachusetts, found that seasonal streams originating in western Oregon grass seed fields provided refuge for native fish and amphibians during the winter high flow periods in Oregon's South Willamette River Basin. Aquatic biota were not harmed by nutrient concentrations in the seasonal streams, and when streambeds were vegetated, invertebrate populations exploded--a boon to fish and bird predators. As the amount of tree cover along these streams increased, so did the abundance and diversity of wintering bird populations. These studies provide farmers with guidelines for identifying where to locate USDA conservation projects to optimize economic and environmental benefits, and provide comprehensive information on managing upland agricultural landscapes in western Oregon watersheds to create habitat for native fish and wildlife—some of which are listed in the Endangered Species Act—on agricultural landscapes. (NP 207, Performance Measure 5.2.6)

Drip application of fumigants in fine textured soils. Field trials conducted by ARS scientists at the Water Management Research Unit, Parlier, California, in commercial certified tree crop nurseries demonstrated that drip application technologies that are comparable to standard shank-injection in coarse textured soils (sandy loams) are not as effective at controlling plant parasitic nematodes as shank-injection in fine textured soils (loam and clay loam). Growers of certified propagative material for orchards and vineyards must be able to produce crops that are free of plant parasitic nematodes at the end of 1- and 2-year crops. Distribution of some fumigants is not adequate following shank-injection in fine-textured soils and drip fumigation is suggested as a possible solution to obtain better distribution of fumigants in fine textured soils. Iodomethane + chloropicrin (pic), 1,3-dichloropropene (1,3-

D) alone, and 1,3-D + Pic were applied by standard shank-injection methods and as emulsified formulations through drip irrigation systems and compared to standard methyl bromide fumigation for nematode control in sandy loam, loam, and clay loam soils. Although nematodes at the 15 and 30 cm depths were killed by drip fumigation, nematodes at the 60 and 90 cm depths survived. Drip fumigation was shown to be inadequate for nematode control for certified nurseries grown on fine textured soils. (NP 308, Performance Measure 5.2.3)

Polyethylene mulch reduces yellow nutsedge population. In greenhouse studies conducted by ARS scientists at the ARS Crop Protection and Management Research Unit in Tifton, Georgia, purple and yellow nutsedge growth was monitored in pots covered with black polyethylene mulch, clear polyethylene mulch, or not covered. Relative to the non-mulched treatments, mulches reduced yellow nutsedge tuber production 50 percent and shoot populations 96 percent, while there were no differences among the treatments for purple nutsedge. Polyethylene mulch can be an important component of a yellow nutsedge management system, while other factors will need to be explored for successful management of purple nutsedge. These results were validated in field trials and integrated into an alternative system of weed management in the absence of methyl bromide. (NP 308, Performance Measure 5.2.3)

Synthetic food-odor attractant for South American fruit fly. A lure mixture of ammonia, methylamine, and putrescine was developed into an attractant for the South American fruit fly. The South American fruit fly is a major pest of citrus and other commercial fruits in South America; its range extends into Central America and Mexico, where it attacks various non-citrus fruits. Better lures are needed to detect, monitor, and eliminate this pest. The chemicals were put into a preliminary formulation and their effectiveness was evaluated in Brazilian citrus orchards, where they produced better results than existing attractants. The work was accomplished through a cooperative project between the ARS Crop Quality and Fruit Insects Research Unit in Weslaco, Texas, and ISCA Technologies, Inc., Riverside, California. An effective lure will result in more effective control of this fly in South America, which in turn will help prevent its introduction into the citrus growing areas of the United States. It will also assist in the detection and eradication of the fly should accidental introduction occur. (NP 308, Performance Measure 5.2.3)

Nematode suppressive cover crops are ineffective in reducing nematode populations of *Meloidogyne floridensis*. *Meloidogyne floridensis* is a recently described species of root-knot nematode isolated in several Florida locations that reproduces on certain root-knot nematode resistant rootstocks, including Guardian, Nemaguard, Nemared, and Okinawa peach rootstocks. Host range studies were carried out by personnel at the U.S. Horticultural Research Laboratory in Ft. Pierce, Florida, to determine whether five commonly-used cover crops and five common weed species can serve as hosts for *M. floridensis*. Good hosts included clover, rape, and cypressvine. Sunn hemp and sesame were poor hosts, while jimsonweed and sorghum sudangrass were nonhosts. This information will be useful for growers who have *M. floridensis* infestations in selecting cover crops and managing weeds for controlling this nematode in the absence of soil fumigation. (NP 308, Performance Measure 5.2.3)

Ultra-low oxygen as a quarantine treatment for iceberg lettuce. Following success in using ultra-low oxygen to control the Lettuce Aphid on lettuce and Western Flower Thrips on broccoli, ARS scientists in Salinas, California, developed an ultra-low oxygen treatment protocol to control Western Flower Thrips on iceberg lettuce that does not injure the lettuce. Postharvest control of Western Flowers Thrips on iceberg lettuce addresses the phytosanitary barriers facing U.S. lettuce in overseas markets. Ultra-low oxygen treatments show strong potential for development as a safe and effective alternative to traditional fumigation for controlling Western Flower Thrips and Lettuce Aphid on exported lettuce, and could increase U.S. lettuce exports.
(NP 308, Performance Measure 5.2.3)

Correct identification of strawberry pathogens. Correct identification of oomycete pathogens from strawberry is a time-consuming process that requires growing out the cultures and then correctly identifying the species based on morphological features—a task complicated by the variation levels that are often observed in some species. Molecular markers (species-specific primers, as well as Restriction Fragment Length Polymorphism analysis) have been developed for identifying *Pythium* and *Phytophthora* spp. recovered from strawberry. ARS scientists in Salinas, California, and Davis, California, are collaborating on trials to adapt this marker system for *Phytophthora* spp. detection in strawberry nursery production, as well as developing specific markers for the three species causing disease in strawberry production systems. Collaborative projects with other ARS and university scientists to use the marker system with other *Phytophthora* spp. are in progress. (NP 308, Performance Measure 5.2.3)

Water seal to reduce fumigant emissions. Two field trials on sandy loam soil were conducted by ARS scientists at the Water Management Research Unit in Parlier, California. Both trials indicated that water seal (spraying water on soil surface following shank fumigation) can reduce Telone and chloropicrin emissions more effectively than standard high density polyethylene (HDPE) tarp at substantially less cost ($800/acre for HDPE tarp versus $300/acre for water seal). In California alone, more than 50,000 acres are fumigated each year, making the cost savings substantial. (NP 308, Performance Measure 5.2.3)

Ozone offers an alternative method for eliminating Black Widow spiders from table grapes. Black Widow spiders are often found in table grapes and must be killed before the grapes are exported. Research conducted by ARS scientists at the San Joaquin Valley Agricultural Sciences Center in Parlier, California, showed that ozone could be utilized to kill the spiders in a short period of time and that the addition of carbon dioxide was not necessary to enhance the efficacy of this method. These results show that using ozone could be an effective method to eliminate live Black Widow spiders from table grapes, making grape importation more acceptable to foreign countries. (NP 308, Performance Measure 5.2.3)

Mechanism of resistance inducement by strain CS-20 to *Fusarium Oxysporum*. Previous research in this project found that *Fusarium oxysporum* strain CS-20 reduced the incidence of Fusarium wilt, caused by *F. oxysporum*, in tomato and other plants. Further, tests demonstrated that the main mechanism of control is resistance in the plant induced by strain CS-20. In fiscal year 2006, research was conducted to identify specific chemical changes induced by strain CS-20. Phenolic compounds are known to be involved in induced resistance in many plants, and four phenolic compounds (vanillic, caffeic and ferulic acids, and an unknown) were found to be produced by tomato roots in response to *F. oxysporum* strain CS-20 (biocontrol strain), but not plant pathogenic *F. oxysporum*. Experiments are in progress to establish the role of these phenolic compounds in induced resistance of tomato to Fusarium wilt. Fundamental knowledge of induced resistance in plants will contribute to development of novel disease management strategies. (NP 308, Performance Measure 5.2.3)

Management Initiative 1: Provide Agricultural Library and Information Services to USDA and the Nation via the National Agricultural Library

Library and Information Services

Increased and enhanced customer services. The Library's total volume of direct customer services grew to over 92 million transactions in FY 2006, a more than 7 percent increase from FY 2005, largely because of increased usage of NAL Web-based products and services. Due to new technology that reduces the number of steps needed to find information on the NAL Web site, the rate of increase in NAL Web hits slowed in FY 2006, and this pattern may continue over the next few years. The redesign and migration of the NAL Web site www.nal.usda.gov following new USDA style guidelines was a major priority for NAL in 2006. In order to accomplish this major priority, an organizational structure to provide leadership and facilitate communications was implemented, and was comprised of an Oversight Committee and six teams: External Relations and Requirements, Existing Web Pages, Landing and Sub-landing Pages, IT Assistance, NAL-Created Web Content Archiving, and the Web Site Taxonomy and Metadata. NAL staff met all USDA-mandated migration deadlines by developing software tools, content templates, and style guidelines needed to transition NAL's 64,000 page Web presence. The new NAL Web site requires fewer steps to find information and also includes a single search box (developed for www.science.gov) to allow users to search NAL databases (such as AGRICOLA) as well as Web pages. NAL developed new and formalized existing Librarywide practices for linking to public facing Web sites. These practices guide agency functions, assure adherence to appropriate quality standards, and comply with maintenance standards required by OMB and USDA. In another important customer service arena, the Library maintained a two-day turnaround time for all document delivery and interlibrary loan requests. The percentage of document delivery requests delivered electronically continues to rise. In FY 2006, 90% of all journal articles supplied by NAL were delivered electronically, an increase of 3% over FY 2005. (National Agricultural Library, Performance Measure 6.1.1)

DigiTop and DigiCALS. During FY 2006, NAL continued to refine and expand digital content subscription offerings to USDA employees around the world through the USDA Digital Desktop Library service (DigiTop). Usage of DigiTop resources continues to increase at a rate of about 13% annually. A total of 678,000 articles were downloaded by USDA employees in FY 2006, indicating the success of this enhanced service. A new metasearch

tool called Central Search was deployed to enhance access and retrieval of DigiTop resources. Numerous in-person and virtual training sessions were conducted at USDA locations throughout the country. During FY 2006, NAL added new scientific journal articles and retrospective backfiles for over 2,660 titles, significantly increasing and expanding the value of this popular service to USDA. NAL continues to pursue sustained funding from USDA agencies to support future development and availability of USDA access to DigiTop beyond FY 2006. Agencies contributed a total of $2.5 million to NAL for this purpose. During FY 2006, the Library's DigiTop-Current Awareness Literature Service integrated current awareness alert services through Dialog and EBSCO, and expanded the USDA user base for the current awareness chargeback services. Further, the USDA DigiTop service integrated full-text (context sensitive) links to select DigiTop subscribed databases using software from Serial Solutions. NAL implemented federated cross-searching solutions to increase the effectiveness of DigiTop user experience. In addition, the DigiTop Web site was redesigned for increased accessibility.
(National Agricultural Library, Performance Measure 6.1.1)

AgNIC. Between October 2005 and spring 2007 the Agriculture Network Information Center (AgNIC) Alliance – www.agnic.org – will have welcomed 8 new member institutions, for a total of 63 members. Four digital content-building projects were completed and four new projects were begun, funded by the AgNIC specific cooperative agreements program, which has funded 23 projects since its inception in
FY 2004. There were about 170 million hits to the NAL servers and AgNIC partner Web sites in FY 2006. For the first time, in 2007 the annual meeting of the AgNIC Alliance will be hosted by a member institution, Mississippi State University. (National Agricultural Library, Performance Measure 6.1.1)

National Digital Library for Agriculture (NDLA) Design Concept Web Site. In 2005, the Library began formal consultations with customers, stakeholders, and potential partners about developing the National Digital Library for Agricultural (NDLA). In 2006, the Library began development of a Web site, expected to be launched by early 2007, for display and testing of a design concept for the NDLA.
(National Agricultural Library, Performance Measure 6.1.1)

Interagency web portal partnerships. NAL will continue its leadership and participation in Nutrition.gov (www.nutrition.gov), Science.gov (www.science.gov), and Invasivespeciesinfo.gov (www.invasivespeciesinfo.gov) in FY2007. These partnerships with other agencies and departments are critical to the fulfillment of NAL's mandate to serve the Nation. (National Agricultural Library, Performance Measure 6.1.1)

AGRICOLA Re-Scope. AGRICOLA (agricola.nal.usda.gov) is the catalog and index to the collections of NAL, as well as a primary free of charge public source for worldwide access to agricultural information. NAL has completed a process of redefining the scope of the AGRICOLA indexing operation to reflect the Library's current capacity and capabilities. Rather than pursue a goal of comprehensiveness, AGRICOLA will focus on indexing information that directly supports the operations of NAL and serves customer needs as much as possible. The combination of items will include USDA publications, articles authored by USDA scientists, core agricultural serial titles, as well as digital and printed content material not indexed by commercial indexing services. The re-scoped AGRICOLA index will continue to serve as the search tool to access NAL's collections and as the search portal to the National Agricultural Library Digital Repository. (National Agricultural Library, Performance Measure 6.1.2)

National Agricultural Library Digital Repository (NALDR). The publishing industry is in the midst of a fundamental shift in modality from printed paper publications to digital publication. This paradigm shift is affecting scientific communications and the nature of performing research. At the core of its mission, NAL must acquire and maintain the scholarly and scientific publications and content required to support agriculture. To fulfill this mandate, the Library must develop the ability to store and preserve in perpetuity digital publications for long-term access. In FY 2006, the Library completed a pilot study and began the implementation of the National Agricultural Library - Digital Repository (NAL-DR). The NALDR (http://naldr.nal.usda.gov) was launched on April 12, providing full text access to publications either digitized by NAL or through NAL's partnerships with other institutions. Over 2,214 volumes (172,175 pages) have been added to the repository thus far, with all documents linked to AGRICOLA. NAL is digitizing, creating metadata for, and storing digitized articles for inclusion in the NALDR. By early 2007, the first articles will be available and will be hyperlinked to AGRICOLA. The following organizations have provided funding for new projects to digitize their publications and provide digital access to

them: The Bean Improvement Cooperative, USDA Agricultural Marketing Service, and the World's Poultry Science Association. NAL will maintain at least one print copy and provide digital access in perpetuity. (National Agricultural Library, Performance Measure 6.1.3)

Purchasing books and journals. The collections of the National Agricultural Library constitute a national treasure and inventory of agricultural information to support USDA and American citizens. Unfortunately, essentially static funding over the past two decades has seriously eroded the Library's budget for purchasing new items for the collections. During this time, the cost of acquiring serials and monographs has increased at rates that exceed core inflation rates and has reduced NAL's materials budget purchasing power by an estimated $1.6 million. In FY 2006, NAL set a minimum funding level of $1.8 million for materials purchases, with a goal of ending the erosion of the collections. To fund the collections at the minimum level, NAL abolished positions and made other budget reductions. This level is the absolute minimum for NAL's collection purchases, below which there can be no pretense of continuing to build a national collection of agricultural information. (National Agricultural Library, Performance Measure 6.1.1)

Cataloging – in –Publication. The NAL cataloging branch is recognized as the premier national authority for description of agricultural books and periodicals. The metadata NAL catalogers create the fundamental building block that permits the identification and retrieval of agricultural information relied upon by libraries across the nation and around the world. In FY 2006, NAL began a partnership with the Library of Congress through which NAL helps catalog new agricultural books prior to their publication. Working from electronic galleys of the book, NAL prepares catalog metadata for inclusion in the printed books. In return, NAL receives a copy of the published work at no charge. When in full operation, this program will permit NAL to acquire 1,000-1,500 books per year with a value of $50,000 to $75,000.
(National Agricultural Library, Performance Measure 6.1.1)

Special Collections Activities. In 2006, NAL hosted an exhibition of botanical illustration art, Inspiration and Translation: Botanical and Horticultural Lithographs of Joseph Prestele and Sons, in conjunction with the Hunt Institute for Botanical Documentation and the US National Arboretum; NAL then published a catalog of the exhibition and developed 16 products for sale based on the exhibition, with a portion of the proceeds funding the conservation treatment of materials within the collection. NAL also produced, in collaboration with Galison publishers, three new products that are based on the nursery and seed trade catalog collection and focus on cherry blossoms. Other 2006 NAL conservation activities included creating protective boxes for 700 items too fragile to re-bind, microfilming 50 requested titles, and photo-duplicating 10 items that are no longer in a condition to circulate. In addition, NAL conserved the papers, watercolors, and lithographs of William Henry Prestele, more than 262 original sketches, watercolors, lithographs, and other works of art, and the sketchbook of Charles Valentine Riley. NAL also hired a contract conservator to complete a collection survey of the USDA Collection and selected rare books. Furthermore, NAL acquired a collection of nursery catalogs that were donated by a retired University of Maryland horticulture professor; the collection includes historic catalogs and two very rare catalogs from Japan that are valued at over $5,000 each. Additionally, NAL staff presented two review sessions of last year's "Reacting to a Water Event" program in preparation for the 2006 hurricane and thunderstorm season. Finally, to accommodate future growth, NAL is installing the remaining shelving for the Abraham Lincoln building special collections fifth floor and moving its rare and valuable items to this floor while rearranging all collections. (National Agricultural Library, Performance Measures 6.1.1 and 6.1.3)

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

obesity prevention, benefits of whole grains, invasive garden species, community supported agriculture, key databases in DigiTop, document delivery, and highlights from the library's Special Collections. (National Agricultural Library, Performance Measure 6.1.1)

Information Centers. The **Alternative Farming Systems Information Center (AFSIC)** published a third edition of the popular digital publication: "*Organic Agricultural Products: Marketing and Trade Resources*," a comprehensive guide to more than 1,000 online information resources about organic markets, marketing, and trade, available in pdf and html on a free CD or at the AFSIC Web site: http://www.nal.usda.gov/afsic . **Animal Welfare Information Center (AWIC)** staff conducted two on-site and eight external workshops to train people to search for information about alternatives to the use of animals in research and held exhibitions at 10 professional meetings. AWIC produced several new Web-based publications and 7 CD information products on animal diseases, farm and lab animal care and welfare, alternatives to animal use, care of pandas, and other key topics for those species regulated under the Animal Welfare Act. **Food and Nutrition Information Center (FNIC)** staff developed a database of recipes (http://foodstamp.nal.usda.gov/recipes.php) submitted by and for nutrition educators working with the population eligible for the Food Stamp Program. Recipe costs are based on information provided by the USDA Economic Research Service (ERS), which purchased data from AC Nielson. **Nutrition.gov,** supported by funding from USDA and HHS agencies, received over 3.3 million hits in FY 2006; this trend is due to improved visibility of the site, resulting from additional Web sites linking to nutrition.gov, and from the addition of metadata to enhance search results. Nutrition.gov received a record high 347,000 hits in February 2006, and a Google search for "nutrition" now shows Nutrition.gov with the #1 ranking. **Food Safety Information Center (FSIC)** staff collaborated with the University of Mississippi's National Institute of Food Service Management to develop an online application for generating HACCP forms specific to food service employee needs. **Rural Information Center (RIC)** staff, in one example of services provided by RIC, provided information about funding sources to a small medical transportation company, which led to the receipt of a grant from one of the foundations. **Technology Transfer Information Center (TTIC)** MTACRADA partner, Artifex Equipment Inc., reported sales of its super slurper book-drying product, Zorbix, to a number of major libraries worldwide as well as to several private conservators. The Special Supplemental Nutrition Program for Women, Infants, and Children (**WIC)** Learning Online Module was approved for 3.9 contact hours for nurses by the Maryland Nurses Association. The pilot version of the International Bibliographic Information on Dietary Supplements (**IBIDS)** Clinical now contains bibliographic records describing studies and organizational statements pertaining to three dietary supplements: chromium, ginkgo, and vitamin E. (National Agricultural Library, Performance Measure 6.1.1)

NAL improves facilities. A major factor in the preservation of library collections and the successful operation of collections-based library programs and services is the condition of their physical environment. In FY 2006, NAL continued to make progress on projects to improve its Abraham Lincoln building in Beltsville, Maryland. Due to safety concerns, repairs to the building's brick façade, which began in FY 2005, were NAL's highest priority modernization project. Available funding supported repairs to three of four sides of the building, which were completed in FY 2006. As part of a USDA-funded security upgrade, a vestibule was installed at the building's main entrance. A project to replace windows on the building's 14th floor was completed in October 2006 to stop leaks around the windows and alleviate problems with moisture building up and dripping down to the 13th floor, where there are stacks containing rare and special collections. Installation of new HVAC and fire suppression equipment for the NAL computer center will be completed in FY 2007. (National Agricultural Library, Performance Measure 6.1.3)