Goal 2: Enhance Economic Opportunities for Agricultural Producers

New Products/Product Quality/Value Added

Development of a soy oil-based metalworking fluid. Biobased lubricant was developed by scientists at Peoria, Illinois, and tested in the private sector CRADA partner's pilot plant, outperformed the equivalent mineral oil lubes, and is economically competitive. The CRADA partner plans to conduct trials next year in large rolling mill plants in the U.S. and Europe. (NP 306, Performance Measure 1.1.1)

Commercially viable procedure to deposit thin layers of starch onto the surface of normally water repellant plastics such as polyethylene. These starch coatings, developed by scientists at Peoria, Illinois, impart water receptive properties to the plastic surface, thereby facilitating the absorption of water-based dyes and inks, reducing electrostatic charging, and improving compatibility with aqueous agents and biological fluids. This technology has applications in plastic containers, biomedical devices, and wrapping materials for sensitive electronic components. The Peoria scientists have filed two patent applications in cooperation with a private sector CRADA partner who is interested in marketing the technology. (NP 306, Performance Measure 1.1.1)

Commercial scale trial demonstrates the use of cotton/flax blend yarns. Yarn developed by ARS researchers at Clemson, South Carolina, in partnership with a commercial textile mill, was woven on high speed weaving machines. The result was commercial quantities of shirting materials and denim with a unique appearance and improved fabric breathability without compromising the fabric strength. The success of this effort demonstrates that domestically grown flax fiber is a good alternative natural fiber source that provides enhanced fabric characteristics for textile mills. It should result in increased amounts of U.S. produced cotton sold for denim garments, and provide manufacturers with a competitive advantage in the global textile market. (NP 306, Performance Measure 1.1.1)

Pilot facilities provide new processes/products. ARS scientists at Peoria, Illinois, constructed a pilot plant facility for developing processing methods to extract new oils from crop seeds. In addition, processes were developed for extracting cuphea seed oil (a potential domestic source of saturated fatty acids for cosmetics), lesquerella seed oil (for engine lubricants), and milkweed seed oil (a potential specialty oil for soaps and cosmetics). (NP 306, Performance Measure 1.1.1)

Improved fungus control for citrus fruit. Researchers at Parlier, California, developed a method to enhance activity of the fungicide imazalil to control green mold while reducing its rate of use by 50 percent or more using sodium bicarbonate. Reducing fungicide use is valuable to reduce industry costs and residues in the citrus fruit ingested by consumers. The technique also accomplished partial control of imazalil-resistant isolates of the fungal pathogen which causes most of the postharvest losses in California. The ARS researchers worked with commercial partners to optimize the combination treatment so that it could be incorporated into commercial use. Some version of the method is now used in most California packinghouses. (NP 306, Performance Measure 1.1.2)

Soluble fibers reduce oxidative damage in test animal tissues. The researchers in Albany, California, discovered that soluble fibers previously thought to be inactive were found to have significant beneficial activity. These results and the new fiber source will provide an alternative to pharmaceuticals to prevent dietary-related metabolic disease such as type II diabetes. The research is being done in collaboration with an industrial partner. Two patent disclosures have been filed. (NP 306, Performance Measure 1.1.2)

Reduced time and expense required to develop wheat cultivars with specific end use traits. Researchers at Manhattan, Kansas, developed a near infrared sorting system that automatically scans individual wheat kernels and sorts them based on specific attributes such as protein content, hardness, amylose content, and other selected quality attributes. The system was commercialized through a Cooperative Research and Development Agreement (CRADA) which is being publicly marketed. The time and expense required to develop cultivars having specific end use traits will be significantly reduced. (NP 306, Performance Measure 1.1.2)

High soluble fiber oat cultivar. ARS researchers at Fargo, North Dakota, collaborated with researchers at North Dakota State University in the development of 'HiFi'. An organic food company will market oat flakes from the cultivar as a health food under an agreement with the University. The company is contracting with several small organic farms to produce HiFi oats. ARS is facilitating the transfer of this technology to the marketplace. (NP 306, Performance Measure 1.1.2)

A decision support system for managing peanut curing operations. This software was developed by researchers at Albany, Georgia, and released for use by the peanut industry, includes models to accurately predict peanut drying time in response to specific drying equipment, weather conditions, and dryer control parameters. It also includes tools to manage the flow of peanuts at the drying facility from the time they are delivered by the farmer until they are graded and marketed. Use of the decision support system will reduce labor, minimize overdrying, and document drying conditions for all peanuts cured at that facility. (NP 306, Performance Measure 1.1.2)

Moisture sensing technology. ARS engineers at Athens, Georgia, consulted with a major manufacturer of farm equipment to develop a new grain moisture sensor for its grain combines, using principles developed by the ARS engineers. Microwave moisture sensing equipment supplied by an instrument manufacturer in Iceland also utilizes principles developed by the ARS. (NP 306, Performance Measure 1.1.2)

Improved understanding of how to reduce the allergenic properties of peanut and peanut products. ARS scientists at New Orleans, Louisiana cloned the gene for and characterized the expression of a major peanut allergen. The allergen was then produced in bacteria. This work provided a model system for evaluating the impact of specific genetic mutations that alter the amino acid structure of the allergen protein in response to roasting and processing. (NP 306, Performance Measure 1.1.2)

Safer, better tasting, more nutritious honeydew. Traditional honeydew melons (netted, orange flesh) have been linked to outbreaks of food-borne illness due to the presence of bacteria within the netting on the exterior surface of the melon. Researchers at Weslaco, Texas, have produced a non-netted, orange flesh honeydew melon that has elevated phytonutrient content, longer shelf-life, better flavor, and greater consumer preference than the traditional honeydew melon. (NP 306, Performance Measure 1.1.2)

Liquid fuel produced from biomass at lower cost. There is an interest in improving the Nation's energy security by replacing imported oil with domestically produced biofuels. The cost of converting lignocellulosic biomass into fuel ethanol, however, makes this renewable fuel not competitive with petroleum-based gasoline. Engineers and scientists at several laboratories working under the ARS Bioenergy and Energy Alternatives National Program have used sophisticated biological techniques to develop new enzymes and fermentation organisms that are more adapted to harsh industrial environments, that more efficiently and economically convert plant biomass to ethanol. These findings will aid in the commercialization of the biological conversion of biomass into renewable fuels and coproducts, and in turn reduce the Nation's dependency on imported petroleum. (NP 307, Performance Measure 1.1.3)

Key gene in cell wall biosynthesis identified. There is a need to identify genes that regulate cell wall composition of alfalfa so that new varieties can be developed that have greater potential as biofuel feedstocks. ARS scientists with the Plant Science Research Unit in St. Paul, Minnesota, identified and characterized a gene, UDP-sugar pyrophosphorylase (USP), that plays an important role in cell wall biosynthesis in plants. The USP gene, found to be widely expressed in plant tissues, was cloned and the properties of the protein it produces were determined. The isolation of the USP gene and new knowledge learned about the protein it produces will allow cell walls of alfalfa plants to be modified to improve the value of alfalfa as a bioenergy feedstock. (NP 307, Performance Measure 1.1.3)

Measuring blends of biodiesel in petrodiesel. Biodiesel is most commonly utilized as a 20 percent blend in petrodiesel (B20), but other blend levels, such as B5 and B2, also are used. Fuel distributors have had a problem maintaining consistent biodiesel blend levels. As the marketing of biodiesel blends grows, easy and rapid methods are needed for determining or verifying the portion of biodiesel in a fuel blend. ARS scientists in the Fats, Oils and Animal Coproducts Research Unit at Wyndmoor, Pennsylvania, developed a

high performance liquid chromatographic method for quantifying biodiesel blend levels of from 1 to 30 percent in petrodiesel that can be completed within 20 minutes. This blend-level measurement procedure could become a much needed standard to help maintain quality control and remove a barrier to biodiesel use. (NP 307, Performance Measure 1.1.3)

Contaminants improve lubricating properties of biodiesel fuel. The properties of biodiesel are affected not only by the fatty acid alkyl esters which are its prime components but also by the remaining contaminants. Biodiesel has been shown to have better lubricating properties than petrodiesel, but the reasons for the improved lubricity are not fully understood. ARS scientists with the Food and Industrial Oils Research Unit at Peoria, Illinois, found that contaminants of biodiesel, such as free fatty acids and monoglycerides, possess better lubricity than neat alkyl esters and are largely responsible for the lubricity of low level blends of biodiesel with petrodiesel. These results aid the design of lubricity enhancing components of fuels that can increase biodiesel use. (NP 307, Performance Measure 1.1.3)

Field pea: A viable fuel ethanol feedstock. Large quantities of renewable feedstocks are needed to offset the large amount of non-renewable petroleum based liquid fuels used in the U.S. Field pea production in northern U.S. is growing and has expanded market potential. Field pea is high in starch and, as such, represents a potential ethanol feedstock. Scientists with the Fermentation biotechnology Research Unit in Peoria, Illinois, developed processes for dry fractionation of field pea into enriched protein and starch streams and for fermenting the pea starch to ethanol. Ethanol yields from pea starch were comparable to that from corn starch, and the enriched protein was similar in protein content to high-protein soy meal, with a well balanced amino acid profile. Both farmers and ethanol producers can benefit from the fuel ethanol potential of this alternate feedstock. (NP 307, Performance Measure 1.1.3)

Feedstock affects biodiesel fuel emissions and performance. Atmospheric emissions from burning transportation fuels are an environmental concern. Use of vegetable oil-derived biodiesel when compared with petroleum diesel consistently reduces emissions of concern except for nitrous oxides (NOx). These increased NOx emissions are a barrier to increased biodiesel use. ARS scientists in the Fats, Oils and Animal Coproducts Research Unit at Wyndmoor, Pennsylvania, found that, when blended at 20 percent with petroleum diesel, biodiesel from animal fats had lower nitrous oxide emissions than did biodiesel from soybean oil. The lubricity and oxidative stability were also better for biodiesel from animal fats; however, the cold temperature properties were poorer. These findings will enhance biodiesel use by helping to properly select and use biodiesel fuels based upon the feedstock from which they were made. (NP 307, Performance Measure 1.1.3)

Livestock Production

Egg-laying chickens can rest on full feed. Egg-laying hens (layers) must go through what is called a “molt” or “molting” in preparation for the next egg-laying cycle. Currently, the molt is induced by withholding feed, which can result in weight loss, reduced egg quality and production once laying begins again, and also raises concerns for animal health and well-being. ARS scientists at West Lafayette, Indiana and collaborators at West Virginia University have shown that incorporating melengestrol acetate (MGA) into a balanced layer diet induces molting, and prevents hen weight loss and hunger, as demonstrated by decreased searching for feed. Inducing molt by MGA, allowed for a quick recovery to peak egg production and increased internal and external egg quality. This research is one of the first to show that hens can be ‘molted’ (reproductively rejuvenated) without causing hunger. MGA is not approved for this application by the FDA. (NP 105, Performance Measure 1.2.1)

The number of broiler chickens in a chicken house impacts growth, but not stress hormones. In the United States, day-old chicks are stocked in poultry houses at densities of 13-17 birds per meter squared, regardless of their projected market weight. Market weights vary from 3.7 to over 9 pounds. ARS scientists at Mississippi State, Mississippi, and collaborators at Mississippi State University conducted research that demonstrated stocking densities of 8 to 13 birds per meter squared exhibit no reduction in growth rate. At a stocking density of 13 to 15 birds per meter squared, a reduction in growth rate occurs, and 95 percent of the reduction is attributable to reduced feed consumption. Further, stocking densities of

8 to 15 birds do not detrimentally impact stress hormone concentrations. This research will aid broiler producer's decisions on stocking density rates for maximal profitability. (NP 105, Performance Measure 1.2.1)

Fish by-product meal contains growth factors. Finding new uses for by-product feeds can save money and reduce environmental wastes by recycling nutrients. Pollock viscera and salmon gonad meal contain biologically-active, non-nutrient components. A team of ARS scientists at the Subarctic Agricultural Research Unit, Fairbanks, Alaska, University of Alaska, and University of Idaho conducted research to enhance the performance of soy-based fish diets by adding meals made from selected fish by-product components. A trout feeding trial was conducted using meals made from different by-products including salmon gonad and pollock viscera in a soy protein diet. Results indicated that by-product meals from gonad and pollock viscera could enhance the performance of a soy protein trout diet. These results demonstrate new uses for under utilized fish by-products and have the potential to reduce the cost of aquaculture diets. (NP 106, Performance Measure 1.2.2)

Cadmium accumulation in oysters is under genetic control. Ongoing international negotiations that could limit cadmium content in seafood may impact the marketability of Pacific oysters. ARS has determined that cadmium accumulation in oysters is under genetic control, and there is a possibility that selective breeding can modify this character. An ARS scientist at Newport, Oregon, in collaboration with an ARS scientist in Corvallis, Oregon discovered significant levels of genetic variation for the bioaccumulation of cadmium in Pacific oysters. Oyster tissue samples were collected for preliminary study of the heritability of cadmium concentration in Pacific oysters from an ongoing quantitative genetic experiment originally setup by collaborators at Oregon State University. These results provide the first evidence for quantitative genetic variation in cadmium bioaccumulation and suggest that this trait could be manipulated by selective breeding. This could enable compliance with potential cadmium limits in internationally traded seafood. (NP 106, Performance Measure 1.2.1)

Use of DNA markers used to establish oyster pedigrees. Current oyster selective breeding protocols require that genetic families be reared separately to maintain pedigree information; and that experiments be highly replicated in order to account for small scale environmental variation. This makes oyster breeding costly and reduces the achievable selection intensity. An ARS scientist at Newport, Oregon demonstrated that pedigrees of Pacific oysters could be reconstructed using a number of DNA markers. The ability to mix oyster families and then reconstruct pedigrees at harvestable sizes could significantly streamline these protocols, reduce costs, and increase selection intensity. (NP 106, Performance Measure 1.2.1)

Taurine identified as a required nutrient for growth of rainbow trout. Taurine was identified as a previously unidentified growth factor present in fishmeal that is not present in plant-derived ingredients. ARS scientists at the Small Grains Germplasm Research Unit, Aberdeen, Idaho conducted research that demonstrated taurine supplementation is required by rainbow trout if fed diets containing protein from only plant-derived ingredients. The supplementation of taurine to these diets improves growth rates, feed conversion efficiencies, protein retention efficiencies and energy retention efficiencies. (NP 106, Performance Measure 1.2.2)

Improved feeding strategies for hybrid striped bass production. Diet recommendations for summer and winter culture of hybrid striped bass (HSB) were developed at the Harry K. Dupree Stuttgart National Aquaculture Research Center, Stuttgart, Arkansas collaboratively with commercial HSB producers. Seasonal extremes in pond temperatures reduce feed consumption and result in deterioration of water quality, wasted feed, stress, disease, and increased cost. The research determined the influence of different diet protein and energy levels on feed consumption and growth in fish reared at temperatures simulating summer (32 C) and winter (8 – 25 C). This work provided essential information for improved production efficiency during summer and winter production in ponds and is now being used by industry. (NP 106, Performance Measure 1.2.1)

A molecular method of aquatic epidemiology. With global development of fish farming, an epidemiological tool is essential to protect the U.S. from possible introduction of variations of bacterial columnaris (Flavobacterium columnare) outbreaks in aquatic species. A technique does not exist to

compare genotypes of this bacteria. Restriction fragment polymorphism (RFLP) and sequencing methods of the 16S rRNA gene and the 16-23S rDNA spacer were developed by ARS scientists at the Harry K. Dupree Stuttgart National Aquaculture Research Center at Stuttgart, Arkansas as an epidemiological tool for bacterial columnaris (Flavobacterium columnare) outbreaks in aquatic species. This method has the advantage of being universal and capable of comparing the genotypes from different geographic locations. The method was used to show the correspondence between the genotypes of isolates in North America to those in Asia and Europe, and for the first time demonstrate the presence of genotype III in the U.S. With increasing movement of fish between countries, this epidemiological tool will be useful to protect the U.S. from possible introduction of new genotypes of this pathogen. (NP 106, Performance Measure 1.2.1)

Information on fish-eating birds communicated to U. S. Fish and Wildlife Service. ARS scientists at the Harry K. Dupree Stuttgart National Aquaculture Research Center, Stuttgart, Arkansas conducted aerial surveys in a fixed-wing aircraft for the fifth consecutive year to document double-crested cormorant, American white pelican, and other fish-eating bird numbers within the catfish production regions of southeastern Arkansas. Trends in cormorant numbers, movements, and duration of use at roosting sites within catfish-producing regions of southeastern Arkansas were determined. This information documented that bird numbers and numbers of roost sites are quite constant, with some variability in the time of year certain roosts are used. This accomplishment provides the U.S. Fish and Wildlife Service (USFWS) reliable data to address and formulate new population estimates necessary for assessing the national cormorant management plan. (NP 106, Performance Measure 1.2.1)

Accurate prediction of algal biomass. Timely and accurate assessment of algal biomass is required to assure optimal conditions for fish grown in high stocking densities. ARS scientists at the Catfish Genetics Research Unit, Stoneville, Mississippi, collaborated with University of Nebraska to develop specific remote sensing models for the highly turbid productive waters found in catfish production ponds. This new model provided greater accuracy of algal biomass estimation than previous models by over 15 percent. This model has application in all inland waters and is particularly useful for rapid assessment of algal biomass in aquaculture systems. (NP 106, Performance Measure 1.2.1)

The released line of channel catfish is further improved. The USDA103 line (family) of channel catfish was developed and evaluated by ARS scientists at the Catfish Genetics Unit in Stoneville, Mississippi, and released under the name NWAC103 to commercial producers in 2001. After two additional generations of selectively breeding USDA103 channel catfish for rapid growth, a new experimental channel catfish line (USDA303) has been developed. Research was conducted to assess growth improvements in the USDA303 line of channel catfish, which showed a marked improvement in growth. Two generations of selection for increased growth has resulted in a 21 percent increase in USDA303 channel catfish body weight compared to USDA103 catfish. Continued improvements in growth through selective breeding will lead to more efficient production for U.S. catfish farmers. (NP 106, Performance Measure 1.2.1)

A new way to immunize fish shows promise. ARS scientists at the Aquatic Animal Health Research Unit, Auburn, Alabama tested their Streptococcus inaie vaccine formulated in feed for its efficacy in tilapia. The results showed that tilapia were protected against experimental challenge with S. iniae. The concept of using an oral vaccine feed appears to be a promising mass immunization method to protect fish against disease. (NP 106, Performance Measure 1.2.1)

Developed a more relevant challenge model. Scientists need ways to test reactions of individual animals to different treatments when raised in groups. Fish have been grouped by fish tank, because identifying individual fish within a tank (treated or untreated) has been very difficult. ARS scientists at the Aquatic Animal Health Research Unit, Auburn, Alabama have come up with a solution. Fish were non-invasively and safely chemically marked and cohabitated with non-marked fish. The chemically marked fish were immunized and non-marked sham immunized. Marked and non-marked fish were challenged with pathogen at the same time in the same aquarium and the efficacy of the vaccine determined by identifying marked and non-marked mortalities. The development of this cohabitation and immersion challenge model simulated production facilities and, since each fish is an experimental unit, increased statistical power to assess vaccine efficacy. (NP 106, Performance Measure 1.2.1)

Dogs trained to detect off-flavor in catfish fillets. Off-flavor (an earthy or musty taste) in catfish production costs the industry as much as $50 million annually. ARS scientists at the Aquatic Animal Health Research Unit, Auburn, Alabama in collaboration with scientists at Auburn University trained dogs to detect odors in water samples associated with off-flavors in catfish. This technology and the dogs with the ability to detect off-flavor compounds were transferred to the Alabama Fish Farming Center in Greensboro, Alabama to determine the potential utility of canine detection of off-flavor in the field. Work this past year demonstrated that dogs were able to smell with 90 percent accuracy if a fish fillet was off or on-flavor. Use of trained dogs could reduce cost of marketing catfish. (NP 106, Performance Measure 1.2.1)

Progress in the Bovine Genome Project. An international project has been underway since 2003 to develop the DNA sequence of the bovine genome. This project has been led by a research team at the Baylor College of Medicine's Human Genome Sequencing Center in Houston, Texas. An international consortium of researchers have been working alongside the Baylor team to develop and carry out this project. Key ARS activities and contributions include: 1) A sequencing effort which is being carried out on the DNA of an inbred Hereford female from the long-term Line 1 inbreeding and selection experiment at ARS' Fort Keogh Range and Livestock Lab at Miles City, Montana; 2) A framework on which to organize the bovine genomic sequence information has been developed by ARS researchers at Clay Center, Nebraska. DNA sequences can now be positioned onto individual bovine chromosomes using the new map permitting the association of sequence differences with economically important traits, such as feed efficiency, meat quality, viability, disease resistance, and reproductive rate; and 3) Tissues from animals related to L1 Dominette 01449, the base DNA source for the bovine genome sequence have been collected by ARS scientists at Miles City, Montana. A wide range of tissues were collected and are being used for the sequencing of cDNAs in collaboration with Genome Canada and others. In addition, Clay Center scientists completed sequencing for 954 DNA fragments predicted to contain the complete protein coding sequence of genes, annotated the gene for its predicted protein sequence and, where possible, gene function, and deposited the DNA and protein sequences in the public database of sequence information at the National Center for Biological Information (NCBI). More than 350 DNA fragments so far have provided the basis for annotated genes in the draft bovine genome. The collective genomic resources developed by the Bovine Genome Project enhance the ability of the international research community to identify important genes and their interactions affecting economically important traits in dairy and beef cattle production. (NP 101, Performance Measure 1.2.3)

Gene mutation identified affecting milk protein percentage in dairy cattle. Percentage of milk made up by the protein is of critical importance to the dairy industry (e.g. for cheese production). Scientists in the ARS Bovine Functional Genomics Laboratory at Beltsville, Maryland, in collaboration with colleagues at the University of Missouri-Columbia, identified a mutation, which may account for variation in milk protein. This marker was found highly useful for genetic selection programs. A provisional patent application for using this polymorphism information in marker-assisted selection was submitted and has been licensed by a multi-national pharmaceutical company who is currently validating its effectiveness in selection to improve this trait. (NP 101, Performance Measure 1.2.3)

Animal germplasm collection strengthened. Samples in the ARS National Animal Germplasm collection at Fort Collins, Colorado, increased 52 percent, and the number of breeds or lines increased 63 percent. In addition, a total of 19 livestock, poultry, and fish populations met minimum collection requirements considered to be adequate to protect the species. These achievements were made possible by the contributions of 170 different livestock producers, public institutions, and companies. Conservation of germplasm resources will make it possible to maintain important levels of genetic variability in the Nation's livestock, poultry, and fish populations. (NP 101, Performance Measures 1.2.1 and 1.2.4)

Validation and technology transfer of the MARC non-invasive beef tenderness prediction system. Previously, the only method to accurately predict whether or not a beef carcass would produce tender or tough steaks was to remove a steak from the carcass and evaluate tenderness mechanically which was costly because of product devaluation. The beef industry has sought development of a non-invasive method for predicting beef tenderness. Scientists at the U.S. Meat Animal Research Center, Clay Center, Nebraska, in collaboration with the National Cattlemen's Beef Association and five beef companies, produced a non-invasive beef tenderness prediction system that was validated in several packing plants

representing a broad sampling of cattle types and processing scenarios. This new technology is expected to have an annual multi-million dollar impact on the beef industry and its consumers. (NP 101, Performance Measure 1.2.1)

Evaluated the impact of dietary perchlorate in dairy cows. Perchlorate is a goitrogenic molecule that has been detected in forages and in commercial milk throughout the U.S. The fate of perchlorate and its effect on animal health were studied in lactating cows. Milk perchlorate levels were highly correlated with perchlorate intake, but milk iodine was unaffected and there were no demonstrable health effects. Results demonstrated that up to 80 percent of dietary perchlorate was metabolized, most likely in the rumen, which would provide cattle with a degree of refractoriness to perchlorate. These results are important for assessing environmental impact on perchlorate concentrations in milk and its relevance to human health and provide important data for agencies assessing health risks of environmental perchlorate. (NP 101, Performance Measure 1.2.1)

Improved accuracy of prion genotyping in sheep. A control panel of sheep DNA was created to increase the accuracy of prion genotyping by research and commercial laboratories. Variation in the prion gene is associated with susceptibility and resistance to Scrapie, a neurological disease of sheep that is similar to BSE in cattle. ARS scientists created a control DNA panel from sheep representing each of 15 prion genotypes associated with susceptibility and resistance to Scrapie. The control DNA panel is used to detect genotyping errors and to improve the quality of genetic information. This valuable resource is helping producers in the United States and other countries to correctly select for genetic resistance to Scrapie and to eradicate Scrapie. (NP 101, Performance Measure 1.2.3)

Development of a panel of DNA markers for swine identification. Individual animal identification is critically important for biosecurity. Until recently, DNA genotyping laboratories did not have access to a set of the most robust DNA markers to uniquely identify animals or accurately determine parentage. Single nucleotide polymorphism (SNP) markers are easily typed with automated, objective techniques that do not rely on human interpretation. ARS scientists at Clay Center, Nebraska developed a subset of SNP markers that was typed across a panel of purebred boars representing U.S. commercial pigs resulting in the identification of 40 suitable markers. This information has been released to 39 different investigators representing scientific and commercial genotyping laboratories around the world. These markers will likely develop the framework of markers used by most commercial genotyping companies to determine identification in pigs. (NP 101, Performance Measure 1.2.3)

DNA marker toolbox for beef tenderness enhanced. Inadequate tenderness is the principal cause of consumer dissatisfaction. Previously, markers for two genes associated with differences in beef tenderness (u-calpain and calpastatin) have been proposed to improve meat quality. It was not known if the effects of these two commercially available gene markers would add together or if the effect of one would be masked by the other. ARS researchers at Clay Center, Nebraska tested these markers in two diverse populations of cattle (both Bos indicus and Bos Taurus) and crosses between these populations. Regardless of the population, the effects of the gene markers on tenderness were nearly independent and therefore both markers can be used to genetically improve tenderness. Additionally, a new u-calpain marker with predictive merit for genetic propensity to produce meat with improved tenderness was developed and released to industry that allows use of the test across all breed populations. This marker is impacting breeding decisions and bull prices and is provided to industry through at least four commercial services. (NP 101, Performance Measure 1.2.3)

Matching beef breed type and stocker production system. Calves from tropically adapted breeds do not perform as well as calves from temperate breeds when used as stocker calves to graze annual cool-season grasses during the winter. Cow herds in the southeastern U.S. are composed of tropically adapted beef breeds that are genetically adapted to tolerate the region's hot and humid climate, but the calves produced on these farms are transported to more temperate climates for growth and development. Post-weaning performance of tropically adapted breeds imported from Africa (Bonsmara) and South America (Romosinuano) were compared to temperate breeds (Charolais, Gelbvieh, Angus and Hereford) by ARS scientists at El Reno, Oklahoma, in collaboration with ARS scientists at Brooksville, Florida, to determine if these imported beef breeds could be used to obtain the needed genetic tropical adaptation in the cow herd

without reducing subsequent winter stocker performance. Tropically adapted breeds gained weight at a slower rate during the winter than other breeds in the experiment when grazed on cool-season grasses. Producers could utilize feed resources more efficiently if the tropically adapted breeds were lot-fed growing rations during the winter, while the temperate breeds were used to graze cool-season grasses. (NP 101, Performance Measure 1.2.1)

Crop Production

Crop genetic diversity conserved and distributed to researchers. During fiscal year (FY) 2005, the 20-plus genebanks in the USDA/ARS National Plant Germplasm System (NPGS) added about 9,000 separate samples of more than 1,000 plant species to its collections, bringing to a total of 465,000 samples from more than 11,300 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 (as of FY 2005) now totalling about 120,000. This is 20,000 more than the average several years ago. These materials are keys for continued progress in crop genetics and breeding requisite for future food security. (NP 301, Performance Measure 1.2.8)

Identification of DNA markers for blast resistance genes in rice. Rice blast is a fungal disease that causes significant crop losses for rice growers worldwide. ARS researchers in Beaumont, Texas, have identified DNA markers associated with resistance to rice blast that occurs in the United States. The markers have been used in cooperation with other ARS researchers at Stuttgart, Arkansas, to identify accessions in the USDA rice collection that have blast resistance. Use of these DNA markers will improve the speed and efficiency of breeding of new varieties with improved rice blast resistance. (NP 301, Performance Measure 1.2.6)

Release of high yielding disease resistant bean germplasm lines. Bean rust is a very significant production constraint in southern and eastern African countries, as well as in Brazil, Central America, Mexico, and the Caribbean. In the United States, bean rust occurs frequently on snap beans in Florida, Tennessee, and other southern states, and on dry beans east of the Rocky Mountains. ARS scientists at Beltsville, Maryland, developed the only pinto beans in the world with four genes for resistance to the hyper variable bean rust pathogen, *Uromyces appendiculatus*, and two genes for resistance to the bean common mosaic (BCMV) and bean necrosis (BCMNV) potyviruses. This germplasm will benefit public and private breeders in commercial seed companies, as well as bean producers and consumers. (NP 301, Performance Measure 1.2.7)

Two new databases created in cocoa germplasm evaluation effort. Epidemic diseases have reduced cocoa production and farmers' incomes by at least 40 percent worldwide. Breeding and selection for disease resistance is the most powerful practical long-term tool to reduce these crop losses. Unfortunately, breeders throughout the tropical world must rely upon disparate cocoa germplasm collections in poorly supported national genebanks. During the last year, ARS scientists at Beltsville, Maryland, assessed the genetic diversity in several important collections. They evaluated over 12,000 plants (individual accessions) and entered the data into two discrete databases – one molecular and one phenotypic. Making this information readily available to plant breeders is essential if they are to produce disease-resistant varieties with acceptable quality and production characteristics. (NP 301, Performance Measure 1.2.8)

New winter malting barley released. ARS researchers at Aberdeen, Idaho, released a new two-rowed winter malting barley variety called “Charles.” This variety addresses problems of limited water supplies and is the first winter barley to exhibit industry specifications for malt quality in pilot scale evaluations. (NP 301, Performance Measure 1.2.5)

Improved germplasm for biobased lubricants. Commercialization of *Lesquerella* – whose seeds contain oil rich in hydroxy fatty acids, an important raw material for making resins, waxes, nylons, plastics, lubricating greases, and cosmetics – is impeded by a lack of superior germplasm for crop production. ARS scientists at Phoenix, Arizona, released a new variety of *Lesquerella* with higher oil content than any other variety. The new line provides public and private researchers additional sources of genetic diversity for future

breeding and an alternative domestic source of hydroxy fatty acids for lubricants currently made from imported castor oil. (NP 301, Performance Measure 1.2.7)

Enabling genetic recombination and genetic mapping in garlic. Because garlic reproduces almost exclusively asexually by means of underground cloves or vegetative topsets, garlic breeding and genetic studies via standard, traditional breeding approaches for germplasm improvement were not feasible. That changed when ARS scientists identified environmental conditions and garlic germplasm conducive to flowering and production of viable seed. This led to their successful development of a system for the production of true seed in garlic, which is currently being used by growers to produce seeds for crop propagation. It also will enable scientists to develop, through genetics and breeding, better garlic varieties, including those with disease resistance. Furthermore, the researchers found that the seeds were the products of "true" sexual reproduction, which makes possible genetic mapping and generation of new genetic variability via two-parent crosses and subsequent recombination. (NP 301, Performance Measure 1.2.6)

Localizing the low-phytic acid gene in the rice genome. Phytic acid in rice grains has a negative impact on animal nutrition and can lead to the excretion of grain phosphates that contribute to water pollution. ARS researchers at Davis, California, have localized the low-phytic acid gene to a small region of rice chromosome 2. This discovery will serve as the basis for developing enhanced rice germplasm providing higher nutritional value and reducing water pollution. (NP 301, Performance Measure 1.2.7)

Release of the first soybean germplasm line with resistance to Charcoal Rot. Charcoal Rot causes significant yield reductions in soybeans. DT97-4290, a high yielding soybean germplasm line with moderately high resistance to charcoal, was released by ARS scientists at Stoneville, Mississippi. Use of this germplasm in soybean breeding programs provides the opportunity to quickly incorporate protection against Charcoal Rot into both public and private varieties, not only across the nine million acres of soybean in the Southern United States, but across the entire U.S. soybean production region. (NP 301, Performance Measure 1.2.7)

Mapping the sorghum genome. ARS researchers at College Station, Texas, in collaboration with Texas A&M University researchers, have completed the cytogenetic map of sorghum. The 10 chromosomes of sorghum were digitally imaged, revealing the genetic architecture of each sorghum chromosome. This work provides a foundation for identifying the gene-rich regions of the sorghum genome. Results will advance the identification of valuable agronomic genes that can contribute to better-adapted and disease-resistant sorghum germplasm. (NP 301, Performance Measure 1.2.7)

New white wheats. Discriminating international customers for U.S. wheat value white flour color and do not want discoloration in wheat food products. ARS researchers at Lincoln, Nebraska, have developed new spring wheat experimental lines without the enzyme polyphenol oxidase, which can cause discoloration in food products. These lines will be made available to all U.S. white wheat-breeding programs. (NP 301, Performance Measure 1.2.7)

Developing effective Integrated Pest Management strategies for peanut production. ARS scientists at Dawson, Georgia, determined the effect of three plant orientations and three disease management schedules on disease incidence (leaf spot, stem rot, peg, pod, and limb rot, and tomato spotted wilt virus), yield, and grade of peanuts. Plant orientations included single row, twin row, and diamond patterns. There were no interactions between plant orientation and disease management, thus disease incidence was not affected by planting orientation. The fungicide program using the "block calendar schedule" provided the most consistent control of leaf spot and stem rot. None of the disease management schedules allowed high disease infestation. Tomato spotted wilt virus was not affected by disease management or plant orientation. Peanuts planted in twin or diamond orientations produced an average of 650 pounds per acre more than peanuts planted in single rows. (NP 301, Performance Measure 1.2.5)

Marking the genes that control soybean oil quality. Commercial production of soybeans with genetically reduced linolenic acid concentration provides the oil supply that fuels an industry-led drive to improve the nutritional quality of food products with low-trans isomer formulations and lower the use of hydrogenated

soybean oil. ARS scientists at Columbia, Missouri, discovered that three genes control the level of linolenic acid in soybeans. The scientists have now developed molecular markers specific for the beneficial genetic mutations in two of these fatty acid desaturase genes (GmFAD3A and GmFAD3C). The use of these mutation-specific molecular markers to identify breeding lines homozygous for these alleles will expedite the development of elite soybean varieties with superior oil quality. (NP 302, Performance Measure 1.2.6)

Understanding genes that control plant architecture. Plant architecture genes control plant structure and effect important traits such as number of flowers, fruit size, and tree shape. ARS researchers at Albany, California, have cloned the *Ultrapetala* genes, which affect bloom formation, and determined that these genes are key players in determining plant architecture. The results can be applied to improve agriculturally important plants for many valuable traits from fruit size to developing fruit trees that are ideal for mechanical harvesting. (NP 302, Performance Measure 1.2.7)

New heat tolerant cotton germplasm with excellent fiber quality. ARS, in conjunction with Cotton Incorporated, released three improved lines of upland cotton to the public for use in breeding new varieties. For the first time, these lines combine some of the excellent fiber quality of Acala-type cottons with the heat tolerance of Delta-type cottons. They can be used as a resource for breeders attempting to improve the fiber quality of mid-south and southeast cottons, as well as for breeders attempting to improve heat tolerance of Acala cottons for the Western United States. (NP 302, Performance Measure 1.2.6)

Hypoallergenic soybean is a natural. Previously, ARS scientists at the Donald Danforth Center in St. Louis, Missouri, demonstrated how to remove the major human allergen in soybean (P34/Gly m Bd 30k) by genetic engineering. The same scientists, in collaboration with the University of Illinois, have now discovered two accessions of conventional soybean in the USDA soybean germplasm collection in which nature has accomplished the same feat by a natural deletion of the gene that encodes the allergen. This finding provides a basis for producing conventional soybeans with greatly reduced allergenicity, especially for uses where genetically enhanced soybeans are not accepted. Work was initiated to breed this and other traits to improve the digestibility and nutritional value of soybean meal into elite germplasm. (NP 302, Performance Measure 1.2.6)

Health benefits of oats. Antioxidant compounds found in oats may have healthful benefits for specific cellular mechanisms. ARS researchers and collaborators at the University of Wisconsin have demonstrated that feeding an oat antioxidant, called avenanthramide, reduced exercise-induced inflammation in rats. Further research to characterize these oat antioxidants will provide consumers with new knowledge about the nutritional value of whole grains and enhance the use and value of oats. (NP 302, Performance Measure 1.2.6)

Removing unwanted transgenes from genetically engineered plants. New genetic technology is needed that allows the removal of unwanted transgenes after their usefulness is ended (for example, antibiotic resistance genes used as selectable markers). ARS scientists in Albany, California, have shown that recombination systems previously demonstrated in yeast also function efficiently in higher plants. This technology is intended to be put in the public domain and made available for general use, so that access to this advance in genetic engineering methods is available to all. (NP 302, Performance Measure 1.2.7)

Discovering genes that protect plants from desiccation. ARS scientists at Lubbock, Texas, have developed a database containing DNA sequence information for genes associated with crop drought-tolerance along with new software tools to assist in data analysis. The database provides new information about the genetic components that confer drought tolerance. This comprehensive profile provides numerous new candidates for dehydration tolerance genes that can be assessed for use in improving the drought tolerance capacity of U.S. crops. (NP 302, Performance Measure 1.2.6)

Sugar metabolism in corn. Enzymes that metabolize sugar affect the value of corn for food and non-food uses. The functional role of genes that encode invertase, a sugar metabolizing enzyme found in corn cell walls, has been determined by ARS researchers at Gainesville, Florida, in collaboration with researchers at the University of Florida. The scientists used biotechnology to examine the effects of eliminating genes for

invertase. Results showed a pivotal role for these genes that can be exploited to enhance the use and competitiveness of corn. (NP 302, Performance Measure 1.2.6)

How plants develop resistance to herbicides. In cooperation with the company SePRO, ARS scientists at Oxford, Mississippi, have determined the genetic basis for resistance of hydrilla (an aquatic invasive plant) to fluridone and similar herbicides. The scientists determined that alteration of the gene for phytoene desaturase (PDS) makes the plants resistant to the herbicides. The results were verified by transferring altered PDS genes into a model plant, Arabidopsis, and confirming that the transformed Arabidopsis plants were resistant to the herbicide. This discovery can be used to develop new strategies for weed control in crops. (NP 302, Performance Measure 1.2.6)

Physiological and genetic responses to tomato spotted wilt virus. ARS scientists at Dawson, Georgia, in collaboration with the University of Florida, developed an innovative strategy for developing peanut germplasm that is resistant to the devastating impact of tomato spotted wilt virus (TSWV) infection. Physiological and genetic responses under heavy TSWV pressure showed that the physiological gas exchange and drought responses of TSWV-infected plants were correlated with specific gene expression products throughout the growing season. This finding will facilitate the improvement of production methods and breeding programs that increase the resistance of peanut to TSWV. (NP 302, Performance Measure 1.2.6)

Honey bee genome sequenced. ARS scientists at Beltsville, Maryland, and Weslaco, Texas, in cooperation with a large international effort, have determined and described coded genes of the honey bee genome which had been sequenced by the Baylor College of Medicine's Human Genome Sequencing Center. The honey bee is the first agricultural and beneficial insect to be sequenced. The annotated genome will be used to improve bee health and pollination efficiency. This effort is crucial, since it comes at a time when the honey bee is being devastated by a variety of invasive parasitic mites (particularly varroa and tracheal mites) and diseases. (NP 305, Performance Measure 1.2.7)

Chemical-free defoliation of cotton for harvest. When cotton is harvested, inclusion of leaves with the fiber causes staining and excessive trash content, both of which greatly reduce the value of the crop. To prepare cotton for harvest, growers spray the crop with a chemical defoliant to remove leaves. Alternative non-chemical methods of defoliation are needed to reduce possible environmental disruption. ARS scientists at Mesilla Park, New Mexico, have developed a propane-fueled thermal defoliator that causes leaf drop by heating the plants. A prototype two-row unit was built, extensively field tested, and shown to perform well under a variety of conditions. With support from the Propane Education and Research Council, a prototype six-row unit was transferred to the private sector in 2005 for further evaluation. The thermal defoliator has the proven potential for an environmentally friendly means of harvest preparation of cotton. Because it uses no chemicals, it is also suitable for organic cotton production. (NP 305, Performance Measure 1.2.5)

Improved bee germplasm for breeding. Eighteen Russian breeder queen lines has been commercially released after a decade of testing to identify useful lines. This population is a genetically diverse group of bees resistant to varroa and tracheal mites, and does not show excessive defensiveness or susceptibility to chalkbrood disease. These breeder lines were developed by ARS scientists in Baton Rouge, Louisiana. In related work, scientists there found that bees with the suppressed mite reproduction (SMR) trait removed reproductive mites more often than they removed non-reproductive mites, supporting the idea that resistance is due, in large part, to discriminative hygienic behavior. This information will better enable researchers to select for this trait and also separate this trait from other mite-resistance traits. (NP 305, Performance Measure 1.2.5)

New antibiotic, Tylosin, has been approved to control foulbrood disease in bees. The bacterium that causes the devastating bacterial disease of bees, American foulbrood, has shown widespread resistance to the only antibiotic currently approved for its control. ARS scientists in Beltsville, Maryland, with cooperation from ARS scientists in Weslaco, Texas, conducted research on Tylosin with regard to animal safety, effectiveness, and human food safety. These studies have led to the acceptance of Tylosin Tartrate by the

FDA. This approval will provide beekeepers across the United States with a new antibiotic to manage American foulbrood disease and will contribute to maintaining the vitality of the U.S. beekeeping industry. (NP 305, Performance Measure 1.2.5)

Produce fresh strawberries for fall and winter. Though there is market demand for fresh strawberries in the fall and winter, most current strawberry production methods produce fruit only in the spring. ARS scientists at the Appalachian Fruit Research Station, Kearneysville, West Virginia, have developed a new transplant propagation technique that causes strawberry plants to flower within 4 weeks after field establishment and that can be used to grow strawberries that fruit in both the fall and the spring. This propagation technique stretches the picking season to late fall when the price is greatest and also lessens the risk of weather-related crop loss. (NP 305, Performance Measure 1.2.5)

Nitrogen improves bare-root nursery tree quality. Defoliants used in commercial production of deciduous, bare-root nursery trees increase the efficiency of harvesting. However, premature leaf fall from use of defoliants decreases plant quality by lowering the amount of nitrogen (N) stored in plants needed for growth the following spring. ARS scientists at the Horticultural Crops Research Laboratory, Corvallis, Oregon, in cooperation with Oregon State University and commercial growers, found that applying nitrogen fertilizer to plant leaves in combination with the use of defoliants effectively defoliates plants while enhancing N storage, which improves plant performance during the following growing season. These findings allow growers the benefits of early defoliation without reducing plant quality. (NP 305, Performance Measure 1.2.5)

Organic production practices for vegetable transplants. Vegetable producers who wish to obtain organic certification must use materials that meet National Organic Program standards. However, information regarding organic vegetable transplant production is lacking. ARS scientists at the South Central Agricultural Research Laboratory, Lane, Oklahoma, used materials that meet National Organic Program standards to develop systems for organic vegetable transplant production. They determined which systems could best be used to produce organic transplants with characteristics comparable to those produced with use of conventional materials. This information allows producers to grow vegetables that comply with organic principles and practices. (NP 305, Performance Measure 1.2.5)

New application method developed for use against chalkbrood disease. Chalkbrood is a disease of bees caused by a fungus that infects bee larvae. Alfalfa leafcutting bees are especially affected by chalkbrood. ARS scientists in Logan, Utah, have demonstrated an easy-to-use method for reducing this disease by treating over-wintering bee cells with fungicide just prior to incubation. Having discovered this new application strategy, new fungicides have a possible utility for alfalfa seed growers who depend on the alfalfa leafcutting bees. (NP 305, Performance Measure 1.2.5)

Reduce pesticide use in nurseries. Pesticides are used to ensure high quality nursery plants meet consumer preferences. However, because many nurseries are in populated areas, possible pesticide contamination of the environment concerns nearby residents. ARS engineers and scientists with the Application Technology Research Unit, Wooster, Ohio, determined that deposits of pesticide, when applied to trees with air blast sprayers, were greater than that needed to control pests. They also measured excessive amount of spray mixture lost on the ground and in the air. Recommendations were developed for proper sprayer setting and for correct pesticide-mix application rates. The findings show potential to reduce by one-half the pesticide and water used in nursery applications. (NP 305, Performance Measure 1.2.5)

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

Food Safety

Risk of Toxoplasma from retail meat is low. There has been an unknown risk of infection to consumers from consumption of meats infected with Toxoplasma gondii, a parasite which may result in birth defects in humans. Scientists in Beltsville, Maryland, completed a National Retail Meat Survey for T. gondii in collaboration with the CDC, and found the prevalence of viable *T. gondii* tissue cysts in retail pork meats to be less than 0.5 percent. None of the beef and chicken meat samples had live *T. gondii* parasites. The National Retail Meats Survey is the first study directly linking pathogen prevalence in animals to consumer risk at the retail meat case. The ARS scientists also found that injection of pork loins with curing solutions prevented transmission of *T. gondii*, which is a further safeguard for many pork products. (NP 108, Performance Measure 3.1.1)

Antiprotozoal screening assay identifies non-drug substances which will kill rumen protozoa. Engulfment of bacterial pathogens, such as *Salmonella typhinurium DT104*, by rumen protozoa increases their virulence. Strategically killing the protozoa will increase both animal productivity and food safety. Scientists in Ames, Iowa, developed an in vitro assay using fluorescent dyes to screen test compounds for their ability to kill rumen protozoa. Using this screen they identified that some natural plant extracts, i.e., yucca and rosemary, effectively control protozoa in the rumen without harming the general fermentation. These plant extracts could greatly reduce the incidence and shedding of Salmonella and other pathogens when used at critical points in the production of both beef and dairy cattle. (NP 108, Performance Measure 3.1.1)

Improved detection method for Mycobacterium avium subsp. paratuberculosis (MAP). This bacterial pathogen, responsible for Johne's disease in cows and sheep, and possibly implicated in human Crohn's disease, is extremely slow-growing and thus difficult to detect via routine bacterial and gene detection methods. Scientists in Albany, California, developed immunomagnetic isolation for MAP. Combining these techniques provides unprecedented speed and sensitivity in detection of the bacteria and will enhance future laboratory studies of MAP. (NP 108, Performance Measure 3.1.1)

Shiga toxin producing E. coli O157:H7 isolated from various fair environments following human outbreaks of E. coli O157:H7. Scientists at Clay Center, Nebraska, collaborated with two State Departments of Agriculture and the CDC in the investigation of human outbreaks of E. coli O157:H7 at fairs and petting zoos in Raleigh, North Carolina, and Tampa, Orlando, and Plant City, Florida. These scientists developed methodology to isolate E. coli O157:H7 from these various fair environments and thus helped determine the likely outbreak vehicle and sources. In collaboration with state officials working at a contaminated fair site, these scientists determined both that E. coli O157:H7 can survive for many months in agricultural soils, that environmental decontamination techniques against E. coli O157:H7 will probably not be 100 percent effective or may even worsen contamination. This information can be used to help keep zoo and fair sites safe for visitors. (NP 108, Performance Measure 3.1.1)

Incorporation of new insect resistance genes into corn promises to reduce mycotoxins. Insect damage and associated ear mold toxins cause hundreds of millions of dollars in losses each year. Scientists in Peoria, Illinois, found plant gene products that either killed insects or enhanced resistance to insects. The corn plants that had high levels of gene products had less damage by caterpillar and beetle pests. Incorporation of these genes into corn should result in reduced levels of mycotoxins, thus increasing both the safety and the exportability of U.S. corn. (NP 108, Performance Measure 3.1.1)

Genes identified for use in selective breeding of Aflatoxin resistant corn. Scientists in New Orleans, Louisiana, and their cooperators in Nigeria, used proteomics (the study of proteins) to identify fungal resistance and stress responsive proteins/genes in corn. Genes encoding many of these resistance associated proteins have been cloned; two have been further characterized. These findings will be used to breed resistance to Aflatoxin into U.S. corn. (NP 108, Performance Measure 3.1.1)

Intervention strategies for fresh-cut produce. Scientists at Beltsville, Maryland, identified a safe and effective new sanitizer (acidified sodium chlorite, or SANOVA) that achieved a 99.999 percent reduction of E. coli 0157:H7, Listeria monocytogenes, and Salmonella serovar poona on produce even in the presence of large organic loads. The researchers optimized sanitation treatment procedures to ensure good quality of shredded carrot and fresh-cut lettuce while maintaining the effective killing power of the sanitizer. These findings are especially useful to the fresh produce industry as they provide practical information in selecting a suitable sanitizer to maintain microbial safety and quality of fruits and vegetables. (NP 108, Performance Measure 3.1.2)

Automated direct sampling and testing. Efficient methods are needed by regulatory agencies to detect pesticide residues in foods to ensure their safety for the consumer. However, a serious issue is the cost of maintaining the testing equipment to ensure it is optimal condition for use. Such costs are often prohibitive for routine testing laboratories. Scientists at Wyndmoor, Pennsylvania, developed a different approach. Called automated direct sample introduction (DSI), it reduces the need for frequent instrument maintenance by eliminating many contaminants before final analysis. This step also improves the detection of the pesticides. Regulatory agencies such as the USDA-Food Safety and Inspection Service that implement this approach will benefit considerably though significant cost savings, ease of use, and by improved detection efficiency. (NP 108, Performance Measure 3.1.2)

Reliability of cooking thermometers. The USDA-Food Safety and Inspection Service (FSIS) is concerned that consumers cook meat products to safe end-point temperatures before consumption. At the request of FSIS, ARS scientists at Beltsville, Maryland, evaluated the accuracy and reliability of temperature indicator devices used by consumers. The thermometers selected were: digital probe, bimetal probe, forks/tongs, remote wireless, as well as disposable indicators that change color at specified temperatures. None of the thermometers tested consistently reached the end point temperature within the manufacturer's recommended time and several models did not reach the end point temperature even after an extended time period. At the manufacturer's recommended time, the remote wireless thermometers were the least accurate. The accuracy of the other thermometers was dependent on the meat product and the cooking method. Because the thermometers indicated that the temperature was lower than the actual temperature, consumers using these thermometers when cooking meat products would actually cook the product to higher temperatures ensuring food safety but may reduce the quality of the product. The FSIS will revise their food safety information on consumer use of instant-read-thermometers to further reduce the potential for foodborne illnesses. (NP 108, Performance Measure 3.1.2)

Portable assay for E. coli O157:H7. Most illness from E. coli O157:H7 has been associated with eating undercooked, contaminated ground beef. There is an urgent need for sensitive, specific, and rapid detection of these bacteria. ARS scientists at Wyndmoor, Pennsylvania, developed a new assay based on a commercially available, portable fiber optic biosensor. This assay is specific for E. coli O157:H7 and can detect very low levels of the bacteria in ground beef within five hours. Higher levels of contamination can be detected in even less time. The biosensor and battery pack can be carried in a briefcase, allowing assays to be performed at the farm, processing plant, distribution center, or retail store. This portable assay provides the food industry and regulatory agencies a new screening tool to detect foodborne pathogens and food security threats. (NP 108, Performance Measure 3.1.2)

Ready-to-eat foods and Listeria monocytogenes. Predicting Listeria monocytogenes in ready-to-eat foods is a high priority for the FDA and FSIS. ARS scientists at Wyndmoor, Pennsylvania, produced models that enable risk assessors and food safety managers to predict the activity of *L. monocytogenes* in delicatessen salads at different storage temperatures and product formulations, and in commercially prepared cheeses. The models assist Federal regulatory agencies in developing risk assessment information for consumers and food companies in designing salad formulations that present lower health risks to consumers. The research has also helped food companies meet new Federal regulations. (NP 108, Performance Measure 3.1.2)

Methods to detect bacteria in seafood. In collaboration with the Haskins Shellfish Research Laboratory, Rutgers University, ARS scientists at Dover, Delaware, developed a new, rapid, inexpensive, enzyme-based assay to detect pathogenic Vibrio bacteria in seawater and shellfish. The assay may be used in identifying peak periods when Vibrio bacteria are at their highest levels in East, West, and Gulf Coast

oysters and growing waters. This would allow regulatory agencies to control shellfish harvesting based on Vibrio bacteria levels rather than using the current fecal coliform levels as indicators of pollution. Since the assay is inexpensive and does not require major equipment it may also find use to screen water quality in aquaculture facilities to forewarn the producer or processor of potential problems so that remedial actions may be initiated. There may also be clinical applications for the assay in quickly screening cultures for the presence of Vibrio bacteria. (NP 108, Performance Measure 3.1.2)

Development of an assay for viruses. Viruses are responsible for a large percentage of foodborne illness in the United States. ARS scientist at Dover, Delaware, developed a real-time molecular method to quickly and easily detect a broad spectrum of Noroviruses (NV), and hepatitis A and E viruses in the stools of infected individuals. This method involves the detection of viral genes through the polymerase chain reaction The assay for example, allows over 90 percent of the strains of NVs circulating in the world today to be detected within 3 hours. Viruses are not only a problem in water and foods such as shellfish, but are commonly associated with outbreaks on cruise ships, Navy vessels, and among troops, particularly during Operation Desert Storm. The technology will have immediate application in both the regulatory and clinical setting. (NP 108, Performance Measure 3.1.2)

Decontamination of melons. Outbreaks of foodborne illness due to consumption of fresh-cut cantaloupe contaminated with bacterial pathogens continues to be a concern to regulatory agency's and industry. ARS scientists at Wyndmoor, Pennsylvania, developed new washing procedure and sanitizer treatments for whole and fresh cut cantaloupe. Hot water surface pasteurization with water at 170F for 3 min using commercial-scale equipment resulted in reduction of *Escherichia coli* and *Salmonella* population in excess of 99.999 percent. Experimental and simulation data on thermal penetration profiles indicated that the internal temperature of melons treated with hot water did not increase rapidly compared to the rind temperature. Edible flesh 10 mm from the surface of the rind remained cool regardless of the process temperature. The data obtained clearly demonstrate the efficacy and utility of this treatment for reducing the risk of foodborne illness from melon consumption, while maintaining sensory qualities and extending the shelf life of fresh-cut cantaloupes. Cut melon pieces could also be directly treated with nisin plus sodium lactate or sodium lactate plus potassium sorbate to effectively reduce pathogen populations without adverse effects on quality attributes. (NP 108, Performance Measure 3.1.2)

New purification/concentration method for Norwalk virus. Norwalk virus is the causal agent of 67 percent of foodborne illness cases in the U.S. and is believed to cause the highest incidence of foodborne illness linked to fresh produce. Because the infectious dose for Norwalk virus is low and the virus cannot be cultured, a highly sensitive method is crucial for its detection in foods. Scientists at Albany, California, developed a method using magnetic beads to concentrate the virus in contaminated samples, and perform gene detection using the polymerase chain reaction to detect the virus. The technology may be used to develop detection kits for public health agencies and the food industry. (NP 108, Performance Measure 3.1.2)

Genome sequencing and source-tracking. Genetic sequencing of microbial genomes yields fundamental information about the organism and is critical for definitive knowledge about pathogens. ARS scientists from Albany, California, in collaboration with The Institute for Genomics Research (TIGR) sequenced the genomes of four different species of foodborne Campylobacter. The sequence data revealed new information regarding the population structure, virulence factors, lateral transfer of DNA, gene regulation, and metabolism of Campylobacter species. The Albany scientists subsequently developed a new genotyping system used to genotype >500 strains of Campylobacter isolated from a variety of sources including humans, animals and food. A strong association between animal host and sequence type was identified and indicated potential biological fitness differences among Campylobacter strains. Genotyping and source-tracking facilitate attribution of human illnesses to animals and possibly foods and epidemiology of outbreaks. (NP 108, Performance Measure 3.1.2)

Pathogen detection in complex food samples. Detection of specific pathogens in complex foods is very difficult, expensive, and time consuming. Mass spectrometry can potentially provide a sensitive and rapid method for analyzing microbes. ARS scientists at Albany, California, characterized over 300 Campylobacter strains through the identification of very specific proteins which are specific to certain

species and sub-species. The technology which can be used for any pathogen of concern, including E. coli O157:H7 and Salmonella, provides a fast, high-throughput method for identifying and differentiating specific species and strains. (NP 108, Performance Measure 3.1.2)

Residue detection on poultry carcasses. Concerns for food safety have required development of more sensitive methods for testing anti-bacterial treatments on raw poultry. New methods are important because poultry processing plants are using a variety of antimicrobial treatments to meet the pathogen performance standards. The use of paired half carcasses as the control and treatment was found to be a more valid microbiological comparison than using different whole carcasses. This method increases efficiency of testing by about 44 percent for the same amount of lab work. The new method is currently being used by industry to evaluate the microbiological impact of novel antimicrobial treatments. (NP 108, Performance Measure 3.1.2)

Transportation of poultry. Campylobacter causes the most cases of bacterial foodborne illness in the USA. Transport coops can serve as a vehicle for transfer of Campylobacter to chickens as they are carried to the processing plant. ARS scientists at Athens, Georgia, completed a study to measure the effectiveness of a low pressure tap water spray followed by an extended dry time to decontaminate the soiled broiler transport coop flooring. The data show that allowing chicken feces which contain Campylobacter to dry on the coop floor dramatically lowers the number of Campylobacter bacteria that can be found later. Coop re-design and implementation by industry could allow more effective decontamination procedures with minimal use of water. (NP 108, Performance Measure 3.1.2)

Shell egg washing. Shell eggs are required to be cleaned/washed before packaging and sent into retail. The current federal guideline in the U.S. requires that the wash water has to be at least 90F or 20F warmer than the warmest egg entering the processing facility. In the hot summer months using wash water at high temperatures can cause the egg to become too hot leading to conditions that allow bacteria in and on the eggs to grow. ARS scientists at Athens, Georgia, in collaboration with scientists at Auburn University examined the effects of using cool water washing of shell eggs on the microbial and physical quality of the final product. The research showed that shell eggs can be commercially processed using cooler water without any reduction in safety. Two additional benefits were that washing with cooler water enhanced the product quality, and it was more cost effective for the typical shell egg washing company to maintain the cooler wash water temperature during processing. A commercial transfer study was conducted in two separate shell egg processing facilities showing the efficacy of the processing change. (NP 108, Performance Measure 3.1.2)

Livestock Protection

Avian coccidiosis and determinants of cross-protective immunity. Coccidiosis is a common intestinal protozoan infection of poultry that seriously impairs the growth and feed utilization of infected birds. It is caused by seven distinct species of intracellular parasites. Anti-coccidial drugs are the primary control method, but drug-resistant coccidia strains are emerging worldwide. Vaccines provide an important alternative to anti-coccidial drug therapy, but existing vaccines, which are comprised of one or more live coccidian species do not provide cross-protection against all seven species. ARS scientists in Beltsville, Maryland, have discovered a protein named SZ-1 that is present in 3 species. The full length gene from *Toxoplasma gondii* was characterized, expressed in a bacterial system, and the protein was used to make antibodies to *T. gondii* SZ1. These antibodies are being evaluated to determine whether this protein provides cross-protective immunity across *Eimeria* strains. (NP 103, Performance Measure 3.2.1)

Genetic determinants of Chronic Wasting Disease (CWD) susceptibility in elk. CWD is one of several Transmissible Spongiform Encepalopathies (TSEs), which includes Scrapie in sheep and BSE (Mad Cow) in cattle. TSEs are unique in that they are not caused by a virus or bacteria, but instead are caused by poorly understood prions that attack the brain. Current control measures for TSEs in livestock depend on identifying the most appropriate tissue for diagnostic testing and identifying animals with naturally resistant genotypes. ARS scientists in Pullman, Washington, in collaboration with Colorado State University and the Canadian Food Inspection Agency, have described the distribution of the CWD prion protein in elk and the genotypes in elk susceptible to disease. The genetic analysis performed by ARS scientists provides the

scientific basis for selecting the brain as the most reliable indicator of disease in elk, in contrast to the tests for deer, which rely on lymphoid tissue. This research also demonstrated the first confirmed case of CWD in an elk of the relatively rare genotype 132LL, thereby ruling out this genotype as conferring resistance to disease under field conditions. (NP 103, Performance Measure 3.2.2)

The pathogenesis of Tibial Dyschondroplasia (TD) which can cause lameness in poultry. TD, a common poultry skeletal problem, causes abnormal cartilage growth in the legs of turkeys and chickens, which when severe can cause lameness. ARS scientists have been investigating the molecular mechanisms of TD, using a disease model that employs thiram (a fungicide) to disrupt cartilage cell growth and differentiation with the goal of finding whether this important skeletal problem can be prevented using nutritional means. The scientists examined the changes in gene expression and the cellular and metabolic alterations in the growth plate during early onset of TD. These studies revealed that TD was not induced by an aberrant pattern of gene expression in the growth plate, but was due to the death of capillary vessel degeneration and cartilage death. These studies provide insight into the pathogenesis of TD, and will help identify nutritional factors that may prevent blood vessel death and development of TD in poultry. (NP 103, Performance Measure 3.2.1)

Optimizing the delivery of poultry Mycoplasma *gallisepticum* (MG) vaccines. Administration of live bacterium as a vaccine to layer chickens has shown that the spray pressure (pounds per square inch; psi) is extremely important in seroconversion (positive blood tests). A survey of the layer chicken industry showed that pressure settings used for the administration of live MG vaccine varied from 35-70 psi. Research conducted by ARS scientists to determine the optimum pressure setting to dispense live MG vaccine. The scientists observed dramatic increases in blood tests for MG colony counts resulting from using the lower (40 psi) setting as compared to the higher 60 psi setting. This information is important as it explains one factor (pressure setting of the vaccinator) that can impact the administration of live MG vaccines that may, in turn, result in poor vaccination results. As a result of poor vaccine test results, re-vaccination must take place, which entails costs of additional vaccine (approximately $1,500/75,000 bird house) and labor. (NP 103, Performance Measure 3.2.3).

New identification methods to assess parasitic infections of ruminants. New methods based on molecular sequence data were developed and by ARS scientists to determine the geographic range, and validated with a site intensive survey and inventory of parasites in ungulate (hooved animal) hosts Protostrongyle nematodes include pathogenic parasites that reside in the lungs, muscles, or central nervous system of their ruminant hosts. Identification based on either adult parasites in tissue and tissue spaces, or larval parasites in feces has hampered a detailed understanding of host distribution and geographic range of the parasites. Such information is critical in defining the potential for disease, and the degree to which parasites may be shared among a number of different animals. A combination of comparative morphology and molecular analyses were used to define the host and geographic range for Parelaphostrongylus *odocoilei* in North America. Molecular identification of larvae indicates that the protostrongylid parasite occupies a broader geographic range in western North America than previously reported. A total of 2,124 fecal samples from 29 locations from thinhorn sheep, bighorn sheep, mountain goats, woodland caribou, mule deer, and black-tailed deer were tested. This study provided significant molecular epidemiological data and represents the first study to combine extensive fecal surveys, comparative morphology, and molecular diagnostic techniques to comprehensively describe the host associations and geographic distribution of a parasite . The development of such “epidemiological probes” will have significant applications in veterinary and wildlife conservation medicine. (NP 103, Performance Measure 3.2.1)

Genetically engineered vaccines to control Swine Influenza Virus (SIV). ARS scientists successfully used reverse genetics to develop a novel cross protective vaccine for Swine Flu. Swine influenza is a re-emerging disease around the world because of several genetic changes in the viral populations. Current commercially available vaccines are not particularly effective. An experimental modified live swine influenza virus (SIV) vaccine was developed as part of a collaborative project with Mount Sinai School of Medicine and St. Jude's Children's Hospital. Preliminary studies indicate this vaccine may have a broader level of cross protection when compared to currently available SIV vaccines that are inactivated or killed. These studies will impact the design of future commercially available SIV vaccines. (NP 103, Performance Measure 3.2.3)

Development of assay to identify insect vectors that transmit Vesicular Stomatitis Virus. Vesicular Stomatitis (VS) outbreaks occur sporadically in the United States with the most recent occurrence last summer. Over 150 cattle and horses were found infected in Montana; ranches and auction barns being temporarily closed in five counties. The symptoms VS are similar to the symptoms of Foot and Mouth Disease. The transmission of the VS virus is poorly understood. The insect vectors in the United States need to be identified to properly control this disease. Scientists from the ARS Arthropod-Borne Animal Diseases Laboratory in Laramie, Wyoming, developed an immunohistochemical assay to detect VS virus in the biting insect, Culicoides midge. Immunohistochemistry is a technique to identify cellular or tissue constituents (antigens) using antigen-antibody interactions within the natural cell environment (in situ). With this assay, VS virus was shown to penetrate natural barriers to infection in both the intestine and salivary gland of the insect. Also, VS virus replication was seen in the developing eggs and salivary glands of the adult insect females, suggesting transovarial (passing the disease through the insect egg to the offspring) and insect bite transmission are likely. Identifying all of the potential insect vectors for VS virus is critical for risk assessments and control of VS outbreaks. (NP 104, Performance Measure 3.2.1)

Determination of flight distance of stable flies. Stable flies are known to be strong fliers, however, little information exists on the distance they disperse from their larval development sites. This information is essential for determining the size of the area that must be included in area wide management programs reduce the number of flies. In a cooperative study conducted by USDA-ARS Midwest Livestock Insects Research Laboratory, Kansas State University, University of Minnesota and University of Nebraska, three stable fly larval sites were marked with fluorescent powder such that the powder would mark flies emerging or visiting the site. Dispersal of the flies appeared to be related to proximity of hosts. Flies emerging from a site next to a feedlot dispersed a mean of 0.1 km whereas those from a larval site remote from hosts dispersed a mean of 0.9 km. These data will be used to develop control recommendations for stable flies as well as to extend research on stable fly biology. (NP 104, Performance Measure 3.2.1)

Discovery of coumaphos resistant *Basophiles microplus* in south Texas. Coumaphos is currently the only pesticide that is registered for the control of the southern cattle tick in the U.S. ARS scientists at the Knipling-Bushland U.S. Livestock Insects Research Laboratory found for the first time ever coumaphos resistant southern cattle ticks in south Texas. These findings were reported to APHIS. Establishment of coumaphos resistant tick populations in the U.S. would be extremely serious to cattle producers and consumers. (NP 104, Performance Measure 3.2.3)

Evaluation of new classes of chemicals for efficacy against horn flies. In a continuing effort to find alternatives to conventional pesticides, research at the Knipling-Bushland U.S. Livestock Insects Research Laboratory is exploring the use of natural products for control of horn flies and stable flies. ARS scientists have shown that azadirachtin, an extract of neem seed with insect growth regulator (IGR)-like activity, is capable of inhibiting production of adult horn flies and stable flies in manure, but is not practical because of its rapid degradation. To avoid degradation of the active agent, new, more stable formulations of azadirachtin have been developed as a feed premix to add to cattle feed. Approximately 6 mg/kg body weight/day was required to provide 50 percent control of stable flies and house flies in the manure of cattle. The ability to incorporate this natural extract into cattle feed could enable fly control. This data will be used to seek FDA registration of the formulations as feed-additives for use as a larvicide against these economically important pests of cattle. (NP 104, Performance Measure 3.2.3)

Biological control of termites in infested trees. Tree based termite colonies are difficult to control and require the application of long-lived chemicals that also have effects on other insect species. ARS scientists from the Formosan Subterranean Termite Research Lab in New Orleans, Louisiana, formulated the fungus *Paecilomyces* in a biologically-compatible foam to treat termite infested trees. The foam allowed the spores of the fungus to be more effectively distributed within the cavity of the tree and thus delivered to a greater number of termites. After a short period of time, the trees were re-examined and colonies of termites in the trees treated with the fungus were no longer active. This research demonstrates the effectiveness of the use of a biological control agent for the control of termite infestation in trees and should allow further development of this fungus as a biological control agent. The adoption of biological

control should reduce the use of long-lived chemicals in the environment with increased specificity of treatments towards termites. (NP 104, Performance Measure 3.2.1)

Evaluation of a fire ant pathogen as a biological control agent. Scientists from the USDA-ARS Center for Medical, Agricultural and Veterinary Entomology (CMAVE), in Gainesville, Florida, the USDA-ARS South American Biological Control Laboratory, and Clemson University have shown that the fire ant pathogen *Vairimorpha invictae* (*V. invictae*) does not infect other ants or other arthropods collected from the same sites as infected fire ants. ARS scientists examined the host range of this pathogen in northern Argentina by collecting ants and other arthropods from four sites where fire ant colonies had high levels of infection (28-83 percent). Non-ant arthropods (235) from 10 orders, 43 families, and more than 80 species were examined, and none were infected with *V. invictae*. Also, 509 ants from 12 other genera, (19 different species) were examined, and none were infected with *V. invictae*. These data indicate that, in its native South American range, *V. invictae* is specific to fire ants. This information is important because it indicates that this pathogen may be able to be released in the U.S. with little or no risk to native ants and arthropods. (NP 104, Performance Measure 3.2.1)

Evaluation of a synthetic blend of compounds as a mosquito attractant. Commercial surveillance traps often do not effectively catch mosquitoes that feed primarily on humans, especially when the trap is placed in proximity of humans. The development of a potent lure that mimics an attractive person to mosquitoes will enhance the surveillance accuracy of traps and allow for a more competitive draw to traps in a local area. ARS scientists at the Center for Medical, Agricultural, and Veterinary Entomology, Gainesville, Florida, have confirmed that the synthetic blend can compete against human odor as an attractant. This represents a significant improvement above any other known trap lures. This work has been submitted for publication and patents have been issued for these blends. (NP 104, Performance Measure 3.2.1)

Crop Protection

Assessing vulnerability of wheat to a new African Stem Rust Mutant. Researchers in St. Paul, Minnesota, Aberdeen, Idaho, and other locations have assessed the vulnerability of U.S. wheat lines to a new, virulent Wheat Stem Rust Mutant that has spread in East Africa. The results of greenhouse evaluations indicated that many hard red spring wheat lines and soft red winter wheat lines from the U.S. are susceptible to the African Stem Rust Mutant. However, resistance was identified in genetic stocks and in adapted germplasm of all classes of wheat. Greenhouse testing was followed by ARS-led screening of U.S. wheat varieties for Stem Rust resistance in Eastern Africa in a cooperative project between ARS and CIMMYT, the International Maize and Wheat Improvement Center based in Mexico City, Mexico. The results of these evaluations are being distributed to all U.S. wheat breeders so they can promptly begin to incorporate resistance into their breeding lines, thus reducing the vulnerability to this potentially threatening stem rust mutant. (NP 303, Performance Measure 3.2.4)

"Rustoleum" soybeans. The invasion of Asian Soybean Rust into U.S. soybean production regions represents a significant threat to the soybean industry. Determining sources of resistance to rust within soybean genotypes is a key priority for the U.S. seed industry. ARS scientists in Fredrick, Maryland and Urbana, Illinois, evaluated nearly 20,000 soybean accessions from the USDA soybean germplasm collection in a plant pathogen containment facility for resistance to Soybean Rust. Approximately 300 to 400 lines showed some resistance and will be tested further with individual rust isolates. Identifying sources of rust resistance is a key step in the development of rust resistant commercial soybean cultivars that can be planted by growers and reduce potential losses should Soybean Rust become epidemic in the United States. (NP 303, Performance Measure 3.2.4**)**

Sclerotinia initiative improves White Mold Management. White Mold caused by *Sclerotinia sclerotiorum* is an economically devastating disease of numerous broad leaf crops throughout the United States. ARS scientists at Fargo, North Dakota, coordinate the Sclerotinia initiative which includes five national commodity organizations (canola, dry bean, pea and lentil, soybean, and sunflower). Accomplishments of

the 35-plus specific cooperative agreements established with 13 land-grant universities, the National Sunflower Association of Canada, and six ARS research locations include:

- Released resistant snap bean breeding line Cornell 501 at the University of Nebraska;
- Transformed Sclerotinia isolates with the green fluorescent protein gene (by scientists at North Dakota State University) to rapidly identify the colonization process on dry bean, canola, soybean, and sunflower;
- Transformed dry bean with the wheat *germin oxalate oxidase* gene (at Michigan State University) to control White Mold infection;
- Revealed two Quantitative Trait Loci (genetic markers strongly associated with highly desirable characteristics) on MLG A1 (Satt050) and G (Satt191) that contribute to resistance to White Mold in soybean (by scientists at Ohio State University);
- Identified six accessions with resistance to White Mold during evaluation of canola germplasm (by scientists at North Dakota State University) in artificially inoculated, mist irrigated field plots;
- Showed (at Colorado State University) that fungicides Topsin and Endura were more efficacious when applied with ground rig or low volume chemigation equipment; and
- Constructed two new cDNA libraries from wild type *S. sclerotiorum* isolate '1980'. The full genome sequence allowed scientists at the University of Florida to generate EST data and additional libraries for data mining or searches for the function of candidate resistance genes. (NP 303, Performance Measure 3.2.4)

Identifying genetic resistance to Stripe Rust in barley and wheat. U.S. wheat and barley producers sustained losses estimated in excess of 100 million bushels in 2005. After screening thousands of U.S. wheat and barley breeding lines from all parts of the country, ARS researchers in Pullman, Washington, have identified 4,000 wheat lines and 500 barley lines with Stripe Rust resistance. This set of identified lines can now be used by plant scientists to identify resistant genes for use by plant breeders to speed up breeding of resistant varieties. (NP 303, Performance Measure 3.2.4)

New therapeutic reagent developed. Coliform mastitis is estimated to cause economic losses of $800 million annually to the dairy industry, and in the absence of effective vaccines, present control relies heavily upon antibiotics and topical germicidal chemicals, which remain sub-optimal. Scientists at the Molecular Plant Pathology Laboratory at Beltsville, Maryland, identified a milk protein – CD14 – that when injected into the udder reduces inflammation caused by bacterial infection. ARS scientists inserted the gene for this protein into a plant virus, which then produced the protein in virus-infected plants. When the purified plant-produced protein was tested in a cell assay and by injection into udders, it functioned in the same manner as the naturally occurring milk protein. This is the first report of a functionally active animal receptor protein made in plants and the use of a plant-derived protein as an animal therapeutic for bacterial infections. (NP 303, Performance Measure 3.2.5)

Soybean dwarf virus detected in the Midwest. In the last 2 years, soybean dwarf virus (SbDV) has been detected in Midwestern soybean fields in association with infestations of the Asian soybean aphid. ARS scientists at Urbana, Illinois, characterized this emerging soybean disease and showed that nearly 50 percent of the red clover plants in Illinois are infected with SbDV. The nucleotide sequences of the genomic regions encoding the coat and read-through proteins of clover and soybean isolates of SbDV revealed that soybean isolates of SbDV from Wisconsin were more closely related to Asian soybean isolates than to clover SbDV isolates from Illinois. Additional experiments will determine whether the sequences differences between soybean and clover isolates are the results of adaptation to new hosts and vector populations, or an indication that red clover is not the source of the soybean SbDV infections. (NP 303, Performance Measure 3.2.4)

Release of soybean germplasm with resistance to multiple pathogens. ARS scientists at Stoneville, Mississippi and Jackson, Tennessee, released an advanced soybean breeding line, JTN-5303, 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 U.S. soybean production regions. Resistance to this pest is a major breeding objective of public soybean breeders. The other diseases can also cause significant yield losses. JTN-5303 was grown in nine states for the USDA Southern Uniform Tests program in 2004

and was one of 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)

Genome-based detection and identification of plant pathogenic 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 pathogen's strains and species, and by lack of knowledge about how phytoplasmas and spiroplasmas survive and cause diseases. Scientists from the Molecular and Plant Pathology Laboratory 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. In preparation for using these biomarkers as targets for therapeutic measures, the scientists also developed new genetically engineered plants capable of synthesizing a foreign protein in specific tissues where the spiroplasma and phytoplasmas live in diseased plants, anticipating future delivery of anti-spiroplasma and anti-phytoplasma proteins to these tissues. 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 3.2.6)

Understanding virulence of Stagonospora blotch. Increased acreage of reduced tillage practices in U.S. cereal growing regions has resulted in higher incidences of fungal diseases of wheat and barley, including Stagonsposora blotch of wheat. ARS researchers in Fargo, North Dakota, have discovered that Stagonospora blotch produces a selective toxin that facilitates disease development and have now mapped the sensitivity locus on wheat chromosome 2D. This sensitivity locus accounts for as much as 60 percent of the disease phenotype in inoculation experiments. This new knowledge of the virulence components of the fungus will assist breeders in developing toxin insensitive and, thus, resistant wheat lines. (NP 303, Performance Measure 3.2.6)

Red flower beetle genome sequenced. This is the first agronomic pest species to be sequenced and represents the joint efforts of the ARS Grain Marketing and Production Center, Biological Research Unit, Manhattan, Kansas; Kansas State University; and the Baylor College of Medicine's Human Genome Sequencing Center. The genome sequence scaffolds were merged with genetic and physical maps, resulting in map position assignment for 75 percent of the genome. Planning and coordination of genome analysis and annotation efforts were initiated at the International Tribolium Genomics Meeting in Gottingen, Germany, in August, 2005. The analysis of this sequence will have far-reaching impact on understanding physiological adaptations of pest and beneficial beetle species, and the identification of novel targets for pest control exploitation. (NP 304, Performance Measure 1.2.7)

Biological control at the ARS overseas laboratories. Invasive weeds and insect pests of foreign origin cause major economic losses (greater than $100 billion per annum) and ecological problems in the United States. Olive fruit fly was first reported in California in 1998 and is now established in olive growing regions in the central part of the state. The fly is capable of infesting 100 percent of the fruit on a tree, rendering the harvest unmarketable. In 2004, a project was initiated at the European Biological Control Laboratory (France), and explorations for natural enemies were immediately conducted in southern Africa. Olive fly parasitoids (small wasps) were identified and sent to University of California-Berkeley and California Department of Food and Agriculture cooperators, who first released the biocontrol agent in 2005. This represents a rapid response to a serious agriculture problem, and, when established, the parasitoids are expected to suppress an insect pest that threatens the growing ($60-100 million) U.S. olive industry. (NP 304, Performance Measure 3.2.6)

Insect identifications prevent introduction and spread of invasive species into the United States. Most U.S. pests have been introduced from other parts of the world and cause billions of dollars in damage annually. In FY 2004, scientists in Beltsville, Maryland provided 11,145 identifications (5,083 of urgent priority) to a broad array of organizations. The vast majority of identifications are provided to the APHIS Plant Protection and Quarantine division. APHIS reports that nine species identified by ARS scientists were new to the United States. In addition, a new species of fruit fly was described from Columbia which will facilitate trade in mangos and other fruit between that country and the United States. In addition, responses to scale pests will now be facilitated by the development of an online expert system which has tools for

accommodating a large amount of morphological variation in specimens. Also, a comprehensive analysis was completed that describes and illustrates all members of the genus *Diuraphis*, including the destructive Russian Wheat Aphid. (NP 304, Performance Measure 3.2.6)

Cooperative area-wide integrated pest management (IPM) tarnished plant bug project shows cotton growers how to manage a serious pest. The tarnished plant bug is a serious pest of cotton that is becoming more resistant to insecticides, requiring growers to use higher and higher levels of chemicals to achieve the same level of control. Within a few years, insecticides may no longer be effective against this pest. The tarnished plant bug is being thwarted thanks to a program that includes use of host destruction, host-plant resistance, fungal pathogens, and remote sensing technology by ARS scientists based in Stoneville, Mississippi, in cooperation with cotton growers and university scientists in Mississippi, Louisiana, Tennessee, and Arkansas. Grower adoption of the technology is 86 percent in the Mississippi Delta and 33 percent in Arkansas, a state where the technology was demonstrated for the first time in 2004. Adoption of the technology is approximately 33 percent in Louisiana and Tennessee. Across the four states, the technology is applied to approximately 1.47 million acres of cotton. A cost/benefit analysis of the program on over 21,000 acres demonstrated benefits of $10.28 for every $1 applied to using the technology. Economists have determined the technology produced a $5.48 savings per acre in reduced insecticide costs. The savings in reduced insecticide costs for the technology was $8.1 million. (NP 304, Performance Measure 3.2.5)

Genetic transformations stabilized. A system was tested that stabilizes certain forms of genetic transformations by ARS scientists at the Center for Medical, Agricultural, and Veterinary Entomology, Insect Behavior, and Biocontrol Research Unit, Gainesville, Florida. The possibility of genes from modified organisms being transferred to other plants or animals has hindered or prevented the application of transformation technology in insect control programs. A new technique was successfully tested in an insect that immobilizes the integrated DNA once it has been transferred. By limiting risk, the "suicide" system has the potential to make new and improved forms of control – such as sexual-sorting strains for sterile insect technique and temperature-sensitive strains that cause the offspring of released insects to die at certain temperatures – available for area-wide management of pest fruit flies and moths. (NP 304, Performance Measure 1.2.8)

Experimental attractant for cactus moth males. A synthetic lure has been developed for cactus moth males based on chemicals produced by virgin female cactus moths by scientists at the ARS Subtropical Horticulture Research Unit, Miami, Florida, in collaboration with ARS scientists in Gainesville and Tallahassee, Florida, and APHIS in Raleigh, North Carolina. A lure for this invasive pest is needed to delimit movement into areas that are currently uninfested and to evaluate implementation of control measures such as mechanical control or use of sterile insect technique. A chemical blend based on chemicals found in the glands and/or released from sexually mature virgin female cactus moths has been formulated into a lure. Laboratory and field tests were conducted to determine release rates and rations of the chemicals, and experimental lures were produced by a CRADA partner for field tests by APHIS. (NP 304, Performance Measure 3.2.6)

Scientists find that selenium, hydrogen peroxide, and Vitamin C provide resistance to baculoviruses. ARS scientists in Columbia, Missouri, were able to show that the budworm requires selenium for optimal resistance to baculovirus infection. As levels of selenium rise after feeding with a selenium-supplemented diet, virucidal activity against baculoviruses also increases. These results indicate that viral ecology may be directly influenced by micronutrients available to leaf eating insect pests both in the soils below and in the species of plants they consume. In addition, the scientists found that the generation of hydrogen peroxide appears to be the mechanism to kill viruses in budworm larvae. Supplements of Vitamin C given to the larvae also abolishes virucidal activity. (NP 304, Performance Measure 3.2.5)

Genetic structuring of corn rootworm populations. The corn rootworm causes over $1 billion in losses each year in the United States. The western corn rootworm has developed a resistance to crop rotation, many insecticides, and may have become resistant to Bt corn as well. ARS scientists in Ames, Iowa, have determined the genetic variation across 10 widely separated populations. The results show that the populations have not had time to drift apart genetically. This knowledge will be used to determine

migration rate and population size of these insects. This information is critical to successful insect resistance management. The related northern corn rootworm has been shown to have genetically distinct populations by ARS scientists in Fargo, North Dakota. This dramatic delineation of populations could possibly be accompanied by extended diapause or increased resistance to Bt corn. This could cause the populations to react differently to control methods. (NP 304, Performance Measure 3.2.5)

Glassy-winged sharpshooter vector potential shown related to insect age, and biological control agents collected and evaluated, and mass produced. ARS scientists in Phoenix, Arizona, determined that an increasing proportion of glassy-winged sharpshooter (GWSS) adults becomes positive for Xylella fastidiosa (the cause of Pierce's Disease) as the insect ages, with correlate increases in titer of the bacterium, thus making older leafhoppers a greater threat. To reduce insect numbers, ARS scientists at Weslaco, Texas, collected and evaluated four species of GWSS egg parasitoids (an insect that parasitizes another insect). The natural enemies were then shipped to the California Department of Food and Agriculture for mass rearing and release. One species, Gonatocerus triguttatus, is now established and spreading beyond the release locations. Such biological control efforts will be aided by progress by ARS scientists at Fargo, North Dakota, in collaboration with scientists at North Dakota State University, who found that GWSS eggs exposed to low temperatures can be used by the parasitoid, Gonatocerus ashmeadi, for production of progeny. These findings will aid in the mass propagation of egg parasitoids for GWSS control. (NP 304, Performance Measure 3.2.6)

Areawide pest management program of Fruit Flies in Hawaii adopted in three demonstration site areas. Growers and cooperators in many areas of Hawaii have adopted the areawide pest management approach. Almost 8,000 acres are currently under suppression. As a result, there has been a dramatic reduction in organophosphate insecticide use in these areas. In related research, the ARS Beltsville Agricultural Research Center, Beltsville, Maryland, has found a synthetic fluorinated analog of Methyl Eugenol that is environmentally more acceptable than Methyl Eugenol. Also, scientists at the U.S. Pacific Basin Agricultural Research Center, Hilo, Hawaii, in collaboration with the scientists in Beltsville, and industry are developing new formulations of the Fruit Fly attractants Methyl Eugenol (Oriental Fruit Fly) and Cuelure (Melon Fly). New trap designs that incorporate more environmentally compatible toxicants, such as Fipronil and Spinosad, as well as pesticide free traps, have been developed for use with these Fruit Fly lures. (NP 304, Performance Measure 3.2.6)

Goal 5: Improve the Nation's Nutrition and Health

Human Nutrition

Popular diets have no special effect on metabolism. Four popular diets were tested for effectiveness and adherence in 160 overweight and obese subjects for weight loss over one year by ARS scientists in Boston, Massachusetts. The diets were characterized as very low carbohydrate, high protein, very low fat, or balanced low calorie. Weight loss was mainly dependent on dietary compliance and the amount of calorie restriction rather than the type of diet. There was no distinct benefit of high protein or limiting carbohydrates or fats. (NP 107, Performance Measure 4.1.1)

Genetic marker for obesity consistent across populations. ARS scientists in Boston, Massachusetts, have for the first time shown that common mutations of a gene called "perilipin" modulate body weight in humans -- and more so in women. This genetic predisposition to obesity has been demonstrated in white Americans randomly selected from the general population as well as in Indians and Malays residing in Singapore. Identifying people with a predisposition to obesity will help in the tailoring of appropriate strategies for obesity prevention. (NP 107, Performance Measure 4.1.1 and 4.1.2)

Fruit and vegetable consumption lowers risk for metabolic syndrome in young adults. ARS scientists in Houston, Texas, found that low fruit and vegetable consumption and high sweetened beverage intake are independently associated with the prevalence of metabolic syndrome in young adults who participated in the Bogalusa Heart Study. Metabolic syndrome, which is characterized by abdominal obesity and the

inability to use insulin efficiently, is believed to be a forerunner of coronary heart disease and type 2 diabetes. (NP 107, Performance Measures 4.1.1 and 4.1.3)

Calcium and vitamin D reduce falls by older Americans. Falls are the largest single cause of injury in older adults aged 65 to 80 years; 90 percent of falls result in fractures. In a three year study, ARS scientists in Boston, Massachusetts, demonstrated that calcium and vitamin D supplementation, in frequently recommended amounts, lowers the risk of falling for this population. Broad-based increases in vitamin D and calcium could help lower health care costs as well as improve the quality of life for older Americans. (NP 107, Performance Measure 4.1.2)

Small deficiencies over time as bad as severe, short-term deficits. ARS researchers at Grand Forks, North Dakota, reported that rats fed marginally-deficient levels of copper for a long time developed cardiovascular damage similar to that seen in animals fed severely-deficient diets for a short period. These results indicate that not meeting dietary recommendations for long periods by a small percentage may be more harmful that previously believed. (NP 107, Performance Measure 4.1.2)

Vitamin K helps reduce osteoarthritis. ARS scientists in Boston, Massachusetts, found that men and women with higher dietary and blood levels of vitamin K have fewer osteoarthritic joints and less abnormal calcification compared to those with lower dietary and blood levels. Ensuring adequate vitamin K intake may potentially reduce this age-related form of arthritis in older men and women. (NP 107, Performance Measures 4.1.2)

Absorption of healthful pigments from plant foods is limited. High fruit and vegetable consumption is associated with a reduced risk for cancer and heart disease, presumably due to the healthful components in these foods. ARS investigators in Beltsville, Maryland, studying the red-purple pigments in specialty carrots found that cooking elevates the absorption of some but not all of these antioxidant pigments and that the body is limited in its ability to absorb these healthful compounds. These findings will help consumers and health professionals plan healthful diets to reduce the risk of chronic disease and avoid unneeded supplementation. (NP 107, Performance Measure 4.1.1)

Soy estrogens affect male hormone pathways. Compounds in soybeans have beneficial health effects that are due to their chemical similarity to the female hormone, estrogen. The most common form of soy estrogen is called genistein. ARS scientists in Beltsville, Maryland, found that genistein reduces activity of genes that respond to male hormones, as well as genes affected by estrogen, in human prostate cancer cells. This finding could help with better dietary recommendations for health. (NP 107, Performance Measure 4.1.1)

Omega-3 fatty acids and fish reduce the risk for cataracts. Age-related cataracts are a major public health problem for Americans accounting for more than 1.3 million cataract operations each year at an estimated cost of about $3.5 billion dollars. In a 16 year study, ARS scientists in Boston, Massachusetts, have shown that a higher intake of total fat appears to increase cataract risk. More frequent consumption of long-chain omega-3 fatty acids and fish can reduce the risk. Dietary prevention of commonly occurring health concerns are a cost-effective and essential way of reducing health care costs in the United States. (NP 107, Performance Measure 4.1.2)

Diets containing unrefined whole grains may lower risk for heart disease. ARS investigators in Davis, California, found that short-term consumption of a diet containing whole grains, in contrast to one with refined cereals and grains, produced a blood lipoprotein profile in women associated with a lower risk for heart disease. If substantiated by a long-term feeding trial, this kind of diet could provide an important food-based strategy for reducing cardiovascular risk. (NP 107, Performance Measure 4.1.1)

Mineral in cells differentiates healthy from cancerous prostates. Zinc is essential to health and needs to get inside cells for it to provide benefits. ARS scientists in Davis, California, have provided the first direct evidence that normal cells accumulate more zinc than cancer cells resulting from differences in the proteins that transport zinc across cell membranes. In addition, these scientists identified the target of selenium in

human prostate cells as a protein of as yet unknown function. These findings may improve the basis for dietary recommendations for health maintenance. (NP 107, Performance Measure 4.1.2)

New and easily accessible nutrient database for the general public. ARS scientists in Beltsville, Maryland, released the "What's in the Foods You Eat Search Tool" on the World Wide Web. In contrast to previous nutrient databases, this one contains nutritional information for those foods most frequently eaten by Americans. Such information aids the consumer in making healthful food choices. (NP 107, Performance Measure 4.1.2)

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

Environmental Stewardship

Biofilters reduce nitrate in drain water. Corn production in tile drained soils leads to high nitrate concentrations in drainage water discharges to streams. ARS scientists in Ames, Iowa, demonstrated that a simple biofilter composed of wood chips buried in trenches adjacent to subsurface tiles can remove 60-70 percent of the nitrate from the tile drainage. The systems are easy to install and do not remove land from crop production. Biofilters could be systematically placed within fields and watersheds where contamination is highest. (NP 201, Performance Measure 5.2.1)

Seepage losses reduced with polyacrylamide. Seepage losses from unlined irrigation canals and ponds exceed 10 million acre-feet per year in the U.S., significantly reducing irrigation efficiency and wasting water. ARS scientists in Kimberly, Idaho, conducted a field study to evaluate the effectiveness of water-soluble PAM and water-absorbent PAM in reducing water losses from an unlined irrigation pond. Seepage losses were reduced by 40 percent with the water-soluble PAM and 60 percent with the water-absorbent PAM. PAM application to unlined canals and ponds would be a low cost technology (< 10 cents per square foot of water surface) to reduce irrigation losses and make better use of the nation's water supplies. (NP 201, Performance Measure 5.2.1)

Detoxification of atrazine. Cost effective methods are needed to remove and detoxify atrazine from soil and water that has been contaminated with the herbicide through accidental spills or overuse. ARS scientists in St. Paul, Minnesota, working with collaborators at the University of Minnesota isolated a bacterial gene encoding an enzyme to detoxify atrazine and modified it for optimal expression. Alfalfa and tobacco plants with the modified gene absorb atrazine and degrade it within the plant, and can tolerate 50 times more atrazine than normal plants. Such plants could be used to economically remove atrazine from a contaminated field or area with less environmental damage than current remediation practices. (NP 201, Performance Measure 5.2.1)

Multiple inlet irrigation for rice. Water requirements for rice are high relative to other crops, and many rice producing areas are experiencing water supply shortages. Nearly all U.S. rice is produced in a flooded culture. The single-inlet approach that is used by most farmers for flooding often leads to wasted water. ARS scientists from Columbia, Missouri, working with collaborators at the University of Arkansas have conducted field scale evaluations of a multiple-inlet approach. They found that it was easier to manage and resulted in a 24 percent savings of water, with no reduction in yield. Widespread adoption of this technology could help to ease water shortages in rice producing areas throughout the world. (NP 201, Performance Measure 5.2.1)

No-tillage cropping systems are as beneficial to soils as conservation grassland in sandy, semi-arid soils. ARS researchers in Lubbock, Texas, monitored a suite of critical soil parameters in conservation grasslands, conventionally tilled fields, and no-tillage fields. They found that no-tillage production fields maintained soil conditions better than conventional tillage and as favorable as those in the conservation grasslands, indicating that farming with proper practices can be as beneficial as placing lands in conservation reserve. (NP 202, Performance Measure 5.2.2)

Site-specific subsoiling saves fuel without reducing yields. In many soils, a form of deep tillage known as subsoiling is periodically needed to maintain cotton yields, but it requires a substantial amount of tractor power, and hence fuel. ARS scientists in the Soil Dynamics Research Laboratory in Auburn, Alabama, found that fuel use could be cut up to 59 percent with no loss in yield if subsoiling was done on a site-specific basis, i.e.- only where needed, rather than across the whole field. Further development of this approach, together with methods to measure and map soil compaction, could result in significant fuel savings and increased profitability. (NP 202, Performance Measure 5.2.2)

Polyacrylamide has no negative effects on soil ecology. Polyacrylamide (PAM) has been shown to substantially reduce soil erosion, but some have expressed concern that its widespread use might have deleterious effects on soil organisms. Scientists in Kimberly, Idaho, tested this concern by applying PAM at a rate of 1 ton per acre, much higher than the normal rate of 10 to 20 pounds per acre. They monitored soil properties, and conducted microbiological analyses for six years and found almost no difference in soil microbial activity despite the massive application rates. This demonstrates that there is no basis for concern about the effects of PAM on soil biota. (NP 202, Performance Measure 5.2.2)

Alternative fumigants stimulate nitrous oxide emission. The use of methyl bromide as a soil fumigant is being phased out due to its role in stratospheric ozone depletion, and other fumigants are being used in its place. ARS scientists in St. Paul, Minnesota, evaluated the impact of the replacement fumigants chloropicrin and methyl isothiocyanate on the emission of the major greenhouse gases, N_2O, CH_4, and CO_2. The fumigants had no effect on CH_4 or CO_2 production, but they stimulated release of N_2O, the most potent of the major greenhouse gases. Thus, while alternatives to methyl bromide may help reduce ozone depletion undesirable greenhouse gas effects may result. (NP 202, Performance Measure 5.2.2)

New wind erosion prediction technology delivered to action agencies. NRCS employees, crop consultants, and others who advise producers have a critical need for software that can predict the impact of management practices on wind erosion. ARS scientists in Manhattan, Kansas, have led in the development of a new, advanced wind erosion prediction model, known as the wind erosion prediction system (WEPS). The software allows growers to select the right approach to prevent erosion. In addition to predicting erosion, WEPS can also predict emission of the tiny dust particles known as PM-10 that may pose risks to human health and the environment. (NP 203, Performance Measure 5.2.3)

Conventional air samplers overestimate particulate matter. The air samplers that are typically used to determine concentrations of small dust particles (PM-10) were originally developed for urban environments. Research at an ARS laboratory in Lubbock, Texas, has shown that these samplers substantially overestimate particulate concentrations. They found that the true concentrations were only 51 percent of the concentration values measured by the samplers. These results indicate that the sampler is not meeting the performance criteria established by the EPA, and that better samplers are needed for accurate determination of dust emissions. (NP 203, Performance Measure 5.2.3)

A new system for measuring soil fumigant emissions. Soil fumigant emissions to the atmosphere need to be measured to predict potential health hazards, but the measurements are expensive and require large investments in time and personnel. ARS scientists in Riverside, California, have developed a new automated sampling system that collects multiple samples without human intervention. This allows scientists to conduct more extensive and complete field investigations of fumigant losses. (NP 203, Performance Measure 5.2.3)

Shelterbelts store carbon both above and below ground. The potential of agroforestry to contribute to carbon sequestration has been suggested, but not previously documented. Previous estimates have focused solely on above ground woody biomass. Thirty-five years after a red cedar/scotch pine shelterbelt was planted in northeast Nebraska, ARS scientists from Ames, Iowa, measured the amount of carbon present in surface soil and plant litter and compared it to soil in adjacent agricultural fields. The shelterbelt had accumulated 2.25 tons of carbon per acre in the soil and litter during the period. Based on previous measurements of carbon accumulated in above ground woody biomass, soil accumulation represented 25 percent of the total carbon storage. These results demonstrate the importance of shelterbelts in mitigating rising atmospheric carbon dioxide levels. (NP 204, Performance Measure 5.2.4)

Night-time CO_2 concentrations affect multiple plant processes. Many studies of the impact of future CO_2 levels on plants have been conducted by growing the plants in CO_2-enriched air, but enrichment is usually only maintained during daylight, on the assumption that photosynthesis is the only affected process. ARS research at Beltsville, Maryland, has shown that, contrary to previous assumptions, CO_2 concentration in the dark affects a number of plant processes, including respiration, translocation, and nitrate reduction. The results will help researchers design more realistic field and laboratory experiments to predict the response of crops to rising atmospheric CO_2 levels. (NP 204, Performance Measure 5.2.4)

Elevated CO_2 protects plants from the negative effects of ground level ozone. Elevated ozone, a major pollutant produced by fossil fuel consumption, suppresses photosynthesis and reduces seed yield in ozone-sensitive peanut varieties. Measurements by ARS scientists in Raleigh, North Carolina, showed that these effects are fully countered by elevated CO_2, indicating that the net effect of atmospheric changes on peanut production will depend on the relative increases of ozone and CO_2 and the ozone sensitivity of the peanut varieties grown. These results will be useful in predicting peanut response to climate change and in choosing proper peanut varieties for specific locations. (NP 204, Performance Measure 5.2.4)

Modifications of plant proteins induced by elevated CO_2. ARS researchers at Beltsville, Maryland, have identified six proteins in Arabidopsis plants that are affected by increased concentrations of CO_2. These findings indicate that, in addition to increasing photosynthesis, the rising level of CO_2 in the atmosphere will directly affect genes involved in plant defense mechanisms and in the regulation of plant development. Results from these experiments and others like them will be useful in predicting plant response to future increases in atmospheric CO_2. (NP 204, Performance Measure 5.2.4).

Improving biodiversity with livestock grazing. Livestock grazing on rangelands has come under attack because grazing is believed to reduce plant biodiversity, adversely affecting environmental quality. Because of the lack of scientific information on how to manage grazing to meet biodiversity goals, ARS scientists at Cheyenne, Wyoming and Miles City, Montana, have conducted long-term studies of plant composition under various livestock stocking rates. In both locations, moderate levels of livestock grazing resulted in the same or higher levels of biodiversity as ungrazed areas. In Montana, non-native plants were found in higher numbers in the ungrazed areas. Therefore, excluding livestock grazing on northern Great Plains rangelands is not the best strategy for improving and maintaining biodiversity and ecological health. (NP 205, Performance Measure 5.1.2)

Managing livestock grazing to avoid poisonous plants. Animal welfare and economic competitiveness are adversely affected when livestock are poisoned by toxic plants. Since eradicating poisonous plants is not usually feasible, livestock producers must learn to manage grazing to avoid poisoning and to recognize the symptoms if it does occur so prompt treatment is possible. ARS scientists at Logan, Utah, compared clinical, biochemical and histological data on how different classes of animals response to locoweed toxicity. They found that horses are especially sensitive, develop severe neurologic lesions, and become hyper excitable and even violent when stimulated. Rodents and deer are relatively resistant with cattle and sheep intermediate in response. This information will be particularly helpful in altering companion-horse owners, particularly those new to managing grazing animals on western rangelands, of the danger to the horses and their handlers. (NP 205, Performance Measure 5.1.2)

Increasing pasture productivity while reducing input costs. The economic competitiveness of American agriculture, particularly for limited-resource farmers, depends on doing more with less. In the southern Great Plains, feeding hay over the entire winter can cost limited-resource farmers as much as a third of farm income. ARS and university scientists at Langston, Oklahoma, evaluated no-till options for seeding cool-season forages into dormant warm-season pastures as an alternative to feeding hay or planting winter forages using conventional tillage. They found that no-till seeding of annual ryegrass increased annual pasture production by 19 percent and if the forage legume, Korean lespedeza was added to the mix, forage production increased by 37 percent. The no-till pastures exceeded conventional tillage for overall production. The combination of reduced hay feeding, using legumes as a nitrogen source and less expensive no-till cultivation reduced costs significantly. (NP 205, Performance Measure 5.1.2)

Ammonia scrubber developed for animal rearing facilities. The air exhausted from animal confinement buildings often contains high levels of ammonia. This represents a potential environmental hazard as well as a loss of nitrogen. ARS scientists in Fayetteville, Arkansas, have developed a small chamber that removes ammonia from the air exiting poultry and swine barns. The chamber is attached to the ventilation fans and is filled with a slightly acidic aluminum sulfate solution. The nitrogen removed can be used to fertilize crops, and the aluminum in the solution precipitates soluble phosphorus and reduces phosphorus in runoff. This technology should help increase yields, improve air quality, and improve water quality. (NP 206, Performance Measure 5.2.5)

Reducing the release of odorous compounds from beef cattle manure. ARS researchers in Clay Center, Nebraska, have shown that high moisture corn in the feed reduces production of odorous compounds from beef manure compared with dry rolled corn, due to a decrease in excretion of starch and malodorous fatty acids. Subsequent production of odor-causing compounds during manure incubation was also reduced. This work confirms that diet modification is an effective strategy for reducing odors from animal operations. (NP 206, Performance Measure 5.2.5)

Alternate host of potato late blight discovered. Potato late blight, caused by *Phytophthora infestans*, is a serious worldwide threat to the potato and tomato industries. Identification of alternate hosts of Late Blight is important for detection of innoculum sources and for effective disease control. ARS scientists in Orono, Maine, examined fields under commercial production for potential alternative hosts. Phytophthora infestans was identified and verified for the first time on hairy nightshade, a common weed. Further studies revealed that the same strain could infect either hairy nightshade or potato. This research shows that management practices to reduce nightshade populations should reduce the occurrence of potato late blight. (NP 207, Performance Measure 5.2.6).

New management practices to replace straw burning in the Pacific Northwest. More than 560,000 acres of perennial grass seed crops are grown in the Pacific Northwest. It has been common practice to burn fields after harvest, but new management practices must be developed due to health and safety concerns. ARS scientists in Pullman, Washington, have shown that perennial grass seed crops can be produced economically without burning by using no-till seeding in combination with chopping back all straw onto the field after harvest. The new system reduces soil erosion by 40-77 percent, reduces nitrate leaching by 50 percent, lowers establishment costs by $27-162 per acre, and allows earlier planting times. (NP 207, Performance Measure 5.2.6).

Methyl bromide alternatives show promise for calla lily production. A four-year, two-location study to evaluate drip applied alternative chemicals for the replacement of methyl bromide for the production of calla lily rhizomes was completed by ARS scientists in Parlier, California, in collaboration with the Golden State Bulb Growers. Alternatives included iodomethane, 1,3-dichloropropene, chloropicrin, and metham sodium and combinations of the above. Significant disease control was achieved compared to non-treated control and was comparable to the standard methyl bromide treatment, although weed control may be lacking when these chemicals are applied by drip irrigation. As a result of this research, drip-applied alternative chemicals are now used in some commercial production in lieu of methyl bromide. Acceptance of these methyl bromide alternatives by growers will increase if results continue to show comparable efficacy to methyl bromide over subsequent harvest years. (NP 308, Performance Measure 5.2.2)

Radio frequency heat treatments offers possibility to control post-harvest walnut pests. To maintain vital foreign markets, walnut processors need a rapid alternative to methyl bromide for disinfesting insect pests of walnuts. ARS scientists at Parlier, California, along with collaborators at Washington State University, University of California-Davis, and Strayfield Limited, have developed a rapid heat method for in-shell walnuts using radio frequency technology. Extensive information generated on the heat sensitivity of the major post-harvest insect pests of walnuts was used to devise a treatment protocol that effectively disinfested the walnuts without affection product quality. The efficacy of the treatment, which has been confirmed in the laboratory, is being tested under commercial conditions in a large walnut processing plant. This treatment has the potential to provide a rapid, non-chemical alternative to methyl bromide, providing the industry with a way to meet the phytosanitary demands of critical markets. (NP 308, Performance Measure 5.2.2)

Phosphine fumigation accepted by Japan as a quarantine treatment for polyethylene wrapped bales of Timothy hay. A phosphine fumigation quarantine treatment was developed by ARS scientists at Parlier, California, for control of Hessian flies in hay. The treatment was the result of three years of collaborative research with the National Hay Association. This treatment will help support a $70 million hay export market with Japan. In addition, certification of the quarantine treatment by the Japan Ministry of Agriculture, Forestries, and Fisheries supports a $360 million market to Pacific Rim countries. (NP 308, Performance Measure 5.2.2)

Ultra-low oxygen treatment disinfests insects on lettuce for export. Ultra-low oxygen treatments were developed for control of western flower thrips and lettuce aphid on iceberg lettuce with minimal or no negative effects on lettuce quality. This research that addresses phytosanitary barriers facing U.S. lettuce in oversees markets and was conducted by an ARS scientist at Salinas, California. The ultra-low oxygen treatment has good potential to be developed into a safe, effective alternative to traditional methyl bromide fumigation for control of western flower thrips and lettuce aphid on exported lettuce and increase export of U.S. lettuce to overseas markets. (NP 308, Performance Measure 5.2.2)

Irradiation quarantine treatment replaces methyl bromide for export of sweet potato from Hawaii to mainland. Formerly, sweet potato could only be exported from Hawaii to the mainland with a methyl bromide fumigation that caused economic losses and could only be done in Honolulu, thereby reducing product shelf life. Recent research by ARS scientists at Honolulu showed that an irradiation dose of 150 gy is sufficient to provide quarantine security against sweet potato pests, and an interim irradiation treatment of 400 gy for sweet potatoes was published as a final rule in the Federal Register awaiting confirmation of the lower dose. Lowering the dose will lower the costs of irradiation treatment and minimize any adverse effects on quality. In the past 2 years, sweet potato production has more than doubled due to the availability of the irradiation treatment, an approximately 2,500 tons of sweet potatoes are currently being exported annually using the irradiation treatment. (NP 308, Performance Measure 5.2.2)

High resolution radiography detects insect pests in apple and cherry fruit. Fruit processed at commercial packing houses may contain internal insect pests that are found while going through the sorting line, which may cause major disruptions of export markets. ARS Researchers at Wapato, Washington and Albany, California, and a radiological technician at the Yakima Memorial Hospital, Yakima, Washington, investigated high-resolution radiography for detection of these pests. X-ray radiographs distinctly show the presence of codling moth larvae in apples and cherry fruit fly larvae in cherries. If successfully scaled to commercial size, this technology offers the opportunity to replace methyl bromide fumigation by eliminating insect infestations on the packing lines before export. (NP 308, Performance Measure 5.2.2)

Mexican fruit fly lure improved. The Mexican fruit fly is a quarantine pest of citrus and better attractants are needed to detect and delimit emerging populations. A lure mixture of ammonia, methylamine, and putrescine developed jointly by the ARS scientists at Weslaco, Texas, and Advanced Pheromone Technologies, Marylhurst, Oregon, was modified for effective use against the Mexican fruit fly in the industry standard trap. The lure was modified to emit more attractive amounts of the active components and to fit into the lure basket of the trap in tests. This lure provides another tool for use in trapping programs to protect citrus from the Mexican fruit fly. (NP 308, Performance Measure 5.2.2)

Compounds tested as replacements for methyl bromide for cut flowers. Dimethyl disulfide is currently under development as an alternative to methyl bromide. ARS scientists at Fort Pierce, Florida, tested dimethyl disulfide on cut flowers and demonstrated that the compound provided control of fungi, weeds, and nematodes in soil at levels comparable to methyl bromide. Efficacy of this material was not affected by fertilization practices. Results suggest this and similar compounds may provide viable alternatives to methyl bromide. (NP 308, Performance Measure 5.2.2)

Biological control of soil pathogen elucidated. Rhizoctonia solani causes root rot of apple and contributes to development of apple replant disease. Scientists at Wenatchee, Washington, conducted studies to elucidate whether Streptomyces spp. have a role in control of R. solani and if so, the mechanism employed by this bacterium to achieve pathogen suppression. Individual strains of Streptomyces provided disease

control which was shown to result from the induction of plant host defense responses, a phenomenon termed induced systematic resistance (ISR). (NP 308, Performance Measure 5.2.2)

Causal agent(s) of prunus replant disease identified. The causal agent(s) of Replant Disease in almonds was thought to be a complex of pathogens. ARS scientists at Davis, California, determined that elevated populations of Cylindrocarpon, Fusarium, Rhizoctonia, and/or Pythium, are associated with incidence of Replant Disease in almond and peach. These results will lead to predictive and novel biologically-based control strategies for management of Replant Disease of stone fruits, thereby minimizing use of soil fumigants and maximizing efficiency of fumigants used to control Replant Disease. (NP 308, Performance Measure 5.2.2)

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 80 million transactions in FY 2005, a more than 20 percent increase from the previous year, largely because of increased usage of NAL Web-based products and services. In conformity with OMB and USDA eGovernment requirements, the new NAL Web site includes enhanced search functionality that will permit searching of NAL databases (such as AGRICOLA) as well as Web pages, from a single search box. This functionality was initially developed for www.science.gov. 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 2005, 87 percent of all journal articles supplied by NAL were delivered electronically, an increase of 4 percent over last year. (National Agricultural Library, Performance Measure 6.1.1)

DigiTop/DigiCALS. NAL has continued to refine and expand digital content delivery offerings to USDA employees throughout the world through the USDA Digital Desktop Library service (DigiTop). The redesigned CALS (Current Awareness Literature Service) service was integrated with DigiTop. New datasets were added, containing electronic journals, online databases, and reference information products. Usage has continued to grow, at an annual rate of over 12 percent. NAL staff have continued to realign DigiTop subscriptions to include primary information products identified by researchers and other staff in contributing agencies, and to eliminate products that had minimal use in the previous year. NAL has upgraded the Web interface by which more than 2,100 journals are available online to USDA staff and researchers. (National Agricultural Library, Performance Measure 6.1.1)

NAL Information Centers enhance services. **Food and Nutrition Information Center/Food Stamps Connection** staff developed a recipe database for nutrition educators working with food stamp eligible populations. The **Alternative Farming Systems Information Center** published the third edition of the popular electronic publication *Organic Agricultural Products: Marketing and Trade Resources.* **Water Quality Information Center (WQIC)** staff continues to update the dynamic and comprehensive series of bibliographies in support of the USDA Conservation Effects Assessment Project (CEAP). **Food Safety Research Information Office (FSRIO)** partnered with the University of Mississippi's National Institute of Food Service Management to develop an online application to generate HACCP forms to meet specific food service employee needs. **Animal Welfare Information Center (AWIC)** staff conducted specialized workshops to help researchers meet the requirements of the Animal Welfare Act by searching for alternatives to using animals in painful/distressful procedures and produced Web and CD information products. **Rural Information Center (RIC)** staff helped a public school, in one of the poorest counties in Maryland, to secure a foundation grant to conduct an obesity education program. (National Agricultural Library, Performance Measure 6.1.1)

Soybean Rust Resource Guide. An online resource guide focused on soybean rust was created by NAL staff. The guide comprises an extensive bibliography of relevant research, links to important resources online, and automated searches of AGRICOLA, USDA and ARS Web sites, and the Internet. USDA now

features the resource guide on its Soybean Rust Information Site. (National Agricultural Library, Performance Measure 6.1.1)

More links from AGRICOLA to Web publications. The number of AGRICOLA records for monographs and serials that are linked directly to either full text or a publisher's Web site increased from 14,683 in FY 2004 to 18,118 in FY 2005, a 19 percent increase. This was accomplished in part by providing access to many USDA publications which were published originally on paper, but are now available on the Web. Also, links from AGRICOLA records for journal articles to publisher and journal Web sites increased from about 41,000 links in FY 2004 to more than 52,000 in FY 2005, a 22 percent increase. (National Agricultural Library, Performance Measure 6.1.2)

Improved AGRICOLA processing efficiency and timeliness. Indexing work flows were reengineered to increase the speed with which articles are processed for AGRICOLA. This was accomplished by the implementation of turbo indexing (a faster approach to indexing) and a simplified method of record processing (creating only partial, non-indexed records). As a result, AGRICOLA currency was improved. Programming to import article level bibliographic data from publishers into AGRICOLA has been completed and some publishers have begun sending article level bibliographic data. Approximately 120 journal titles from two publishers are now being processed this way, with more titles from additional publishers to follow. Once this program is in full operation, customers will have much more timely access to the literature of agriculture, and fewer bibliographic records will need to be keyed by NAL staff or contractors. NAL has also been piloting machine-aided indexing software to determine if it can be used to assist indexers, thus increasing indexing productivity, and to provide subject indexing without indexer intervention. (National Agricultural Library, Performance Measure 6.1.2)

National Agricultural Library Thesaurus work supports AGRICOLA and USDA E-Gov. The 2005 edition of the *NAL Agricultural Thesaurus* was published at http://agclass.nal.usda.gov/agt/agt.htm on January 1, 2005. The edition contains approximately 63,800 terms and includes improvements to the thesaurus by adding new terminology of particular interest to USDA. Invasive species vocabulary was expanded this year as well as the enzyme nomenclature which was aligned with the current recommendation of the Nomenclature Committee of the International Union of Biochemistry and Molecular Biology (IUBMB). Other additions and improvements to the thesaurus came from incorporating suggestions from users, adding definitions and scope notes to terms for clarity, and incorporating taxonomic changes, including a major revision of terminology about Salmonella. A mirror site of the *NAL Agricultural Thesaurus* was established at the College of Agriculture and Natural Resources (CANR), Michigan State University. The 2006 edition of the *NAL Agricultural Thesaurus* will be published on January 1, 2006, and will include an expansion and alignment of the insect taxonomy prepared in collaboration with the Entomological Society of America. (National Agricultural Library, Performance Measure 6.1.2)

NAL participates in the Lots of Copies Keep Stuff Safe (LOCKSS) initiative. NAL maintained currency with the latest versions of the software for the Lots of Copies Keep Stuff Safe (LOCKSS) initiative, a collaborative digital preservation demonstration project led by Stanford University. NAL also began participation in the LOCKSS program as part of the LOCKSS/DOCS program, working collaboratively with the Government Printing Office, Stanford University and other universities in an effort to provide long-term access to government documents. NAL's participation in the LOCKSS demonstration program is important in exploring options for providing citizens long-term access to digital government information. This pioneering effort to address the issues of long-term storage, authenticity, and access for digital information is a distinct technological challenge. The LOCKSS program has proven the ability to capture and maintain the electronic copies of documents and periodicals. The current focus of this initiative is to determine how to solve the problems of distributing the information from our LOCKSS server to USDA staff. Our unique USDA nation-wide user network is posing technical programs that have not been encountered before by LOCKSS. The resolution of this issue is our program priority for FY07. (National Agricultural Library, Performance Measure 6.1.3)

Exhibition at Hunt Institute for Botanical Documentation. "Inspiration and Translation: Botanical and Horticultural Lithographs of Joseph Prestele and Sons." The exhibition features the botanical works of Joseph Prestele and his sons, was drawn from the collections of NAL, the Hunt Institute and items on loan

from descendants of the Prestele family. The exhibition, which opened at the Hunt Institute on September 8 will move to NAL in early 2006, includes watercolors, drawings, lithographs, and account books documenting their work for botanists and horticulturalists of the late 1800s. A significant group of Prestele manuscript material received conservation treatment for this exhibition. NAL and the Hunt Institute also published the 84 page exhibition catalog. (National Agricultural Library, Performance Measure 6.1.3)