Annual Report of Accomplishments
And Results

Agricultural Research Programs
Purdue University

Federal Fiscal Year 2006

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A. PLANNED PROGRAMS

GOAL 1. AN AGRICULTURAL PRODUCTION SYSTEM THAT IS HIGHLY COMPETITIVE IN THE GLOBAL ECONOMY

Overview: Efforts are underway to re-energize the Indiana agricultural sector and rural communities. A viable crop, livestock, and natural resource system is essential for the success of the Indiana economy. Livestock production (especially swine and dairy) is increasing and investments are being made to expand the Indiana biofuels industry, including construction of a large biodiesel plant and several new ethanol plants about to come on-line. In 2005 (the most recent year available), Indiana net farm income was $1.4 billion (about 1%) of Indiana's GDP. The primary focus of the Strategic Plan of the Indiana State Department of Agricultural is to: 1) develop the Indiana hardwoods industry, 2) increase biofuel production and use, 3) expand the food processing sector, 4) double pork production, 5) increase diversity of production, 6) enhance regulatory coordination, and 7) increase the role of state government in farm and trade policy. (www.in.gov/isda) Purdue University, through its world-class research and extension efforts, is making significant contributions towards the attainment of these goals.

For 2005 (the most recent year available), cash receipts for Indiana agriculture were $5.58 billion with 63% from crop sales and 37% from livestock sales. (www.nass.usda.gov/Statistics_by_State/Indiana/index.asp) In 2005, Indiana ranked 20th in acres of land in farms, but ninth nationally in crop receipts. The 59,000 farms in Indiana represent 2.8% of all U.S. farms. In 2005, Indiana agricultural exports were estimated at $1.85 billion, about 3% of total U.S. agricultural exports. Despite being a relatively small state with only 1.6% of total U.S. cropland, in 2005, Indiana ranked second in processing tomatoes, popcorn, egg-type chicks hatched, and ice cream production; fourth in soybeans, spearmint, peppermint and total eggs produced; and fifth in corn, fresh market cantaloupe, and hog inventories. The challenge for Indiana farmers is to adopt and manage agricultural production practices that are environmentally sound, yet allow them to remain competitive in a dynamic global economy. This is especially critical as Indiana attempts to double hog production over the next 20 years as outlined in the Indiana Department of Agriculture's Strategic Plan. Approval of construction permits by the Indiana Department of Environmental Management and site approval by local zoning committees have become very controversial issues as the state attempts to balance agricultural-based employment and income-generating opportunities with community concerns about environmental quality. In the 2006 crop year, Indiana growers set near record yields second only to 2004, and the livestock sector enjoyed continued economic success.

Indiana is a leader in the life sciences with increased public and private sector coordination and planning. The newest research buildings in Purdue University Discovery Park are dedicated to life sciences, biomedical engineering, and nanotechnolog research. Biotechnology is providing a new frontier for agriculture, food, and forestry systems. To date, the genomes of many higher plants, microbes and insects are known. Several Purdue faculty are world-renowned experts in plant, animal, and insect genomics. Purdue University scientists are leading the way in genomics, proteomics, metabolomics, nanotechnology, and a state-of-the art hardwood genomics effort. In 2006, 40% of the field corn and 92% of the soybeans produced in Indiana were transgenic varieties. Purdue University researchers seek to understand and exploit the genetic basis for plant, animal, microbial and insect form and function. Fundamental and applied research in genomics, proteomics, molecular biology, and bioinformatics are the foundation for the development of value added/identity preserved products. Purdue University scientists are engaged in a wide array of genetic research including sequencing the soybean genome and Arabidopsis gene function discovery. Such discoveries can help increase the profitability for farmers and the entire food value-chain by improving the productivity of crops and livestock, and adding value to agricultural products.

Plant productivity is challenged by numerous biological and non-biological stresses. Purdue University is making a significant investment in research to mitigate the impact of potential economic losses from pests and plant stress. Several multidisciplinary teams of scientists are studying pests, such as the Western corn rootworm which has recently adapted and evolved to counter crop rotation as a biological control strategy, thus resulting in damage in first-year corn. Consequently, soil insecticide and insect-resistant GM corn hybrids are being adopted by many Indiana growers. Invasive species periodically enter our agricultural system. The soybean aphid, first discovered in Indiana in 2000, is becoming a major pest in northern Indiana. Purdue University researchers are exploring a variety of approaches to reduce potential pest losses including genetic resistance to pests, biological control, and Integrated Pest Management strategies. In 2006, applied research and extension experts conducted educational programs in cooperation with the Indiana Soybean Alliance on alternatives to combat soybean rust which was first detected in Indiana in 2006.

The 1996 Food Quality Protection Act has resulted in the cancellation of pesticides important in agricultural production. Also, public opinion on the use of transgenic methods to create plants that resist pests has placed new constraints on pest management. Purdue University scientists have been successful in several key pest management arenas, for example, the biological and economic implications of the suppression of the Western corn rootworm variant, evaluation of apples with resistance to a primary pathogen (scab), genetically improved wheat varieties to control the yellow barley dwarf disease, biological control of soybean aphids, and non-pesticide alternatives such as CO_2 and ozone to manage pests in stored grain. Some of these pest management techniques are appropriate for organic production systems.

The challenge of ensuring the health and well being of animals, while maintaining maximum production remains important to Indiana producers. Purdue University researchers are working to ensure that livestock are raised under conditions that minimize diseases and stress, maximize productivity, reduce environmental pollution, and are managed in ways acceptable to consumers. Researchers are working to reduce excess nitrogen and phosphorus in animal manure and finding ways to improve the well-being of swine while making them more productive. Purdue University is leading a national air emissions research initiative in collaboration with the EPA to measure actual on-farm emission levels of ammonia, hydrogen sulfite, and particulates in order to establish science-based regulatory guidelines for livestock producers. User-friendly computer models are being developed to help producers and regulatory authorities determine appropriate sites for new confined animal feeding operations (CAFOs).

U.S. agriculture is challenged by a very competitive global economy, especially in Latin America and potentially in Asia. Major contributors to the globally competitive position of U.S. agriculture include the development of biotechnology, rapid international flow of capital, changes in business structure, international trade agreements, domestic agricultural and environmental policies, rapid advances in information systems, just-in-time transportation systems, and electronic marketing systems. Purdue University economists are developing sophisticated computer algorithms to track and analyze these international trends.

Evolution of business practices, market power by concentrated agribusiness firms, adoption of transgenic crops, and the emergence of precision farming technology have added yet another new dimension of complexity and opportunity for producers and agribusinesses. Purdue University researchers are engaged in studies on the socioeconomic impacts of state and federal policies as well as the evaluation of different tactics and strategies for producer and business enterprises in this emerging global economy.

Purdue University research is closely linked with various stakeholders and extension educators around the state. For example, the use of soy-diesel is increasing in Indiana, in part as a result of the research conducted at Purdue University, and our close collaboration with the Indiana Soybean Alliance. The Indiana Soybean Alliance not only funds applied research, but also has provided financial support for an endowed chair at Purdue University in soybean utilization. Research programs are also addressing ways to use carbohydrates and oilseeds to make industrial products, such as substitutes for petroleum-based polymers, bio-based fuels, or enhancing the

nutritional quality of grains for livestock. Other researchers are looking for new uses of agricultural products and by-products as feed for livestock and fish. A team of experts is exploring the technical and business implications of the rapidly expanding ethanol industry in Indiana. Particular attention is being given to the use of DDGS (distillers dried grain with solubles) from ethanol plants and glycerol from biodiesel production in livestock rations. Teams of Purdue scientists competed for about $250,000 of internal funds to conduct integrated applied research/extension efforts to address some of these emerging issues such as biofuels and expansion of the livestock sector that are of critical importance to Indiana stakeholders.

Successes:

- Dairy genetic research is finding ways to increase milk production and cow fertility.
- Modification of swine rations can increase feed efficiency and reduce ammonia and hydrogen sulfide emissions.
- The use of diet acidification can partially replace in-feed antibiotics in nursery pig diets.
- By using DNA to study wildlife in their native habitat it is possible to gain a more accurate picture of their natural history and diversity.
- Searching in the honey bee genome for stinging behavior has been narrowed to about 40 genes.
- Understanding of the fundamental stomatal control of water loss from leaves may lead to the identification of molecular-genetic approaches to controlling water efficiency in crop plants.
- Improved understanding of polyamines will help improve the nutritional attributes and shelf-life of ripened fruits.
- Three wheat releases have moderate resistance to Fusarium head blight and yellow dwarf virus.
- Volatile compounds released from leaves, flowers, and fruits, which play a vital role in plant life as attractants, repellents, and signal molecules, have been isolated and characterized.
- Impacts of waterlogging for various turfgrass species on turf quality, root dry weight, and carbohydrate and protein content have been measured, resulting in varietal recommendations to professional turf managers.
- Overproduction of compounds that absorb UV radiation appear to reduce the ability of the corn plant to produce seed.
- Data were collected for the development of a weather-based, risk model for Fusarium head blight in wheat to guide growers' fungicide applications.
- Crypreservation of semen will help maintain the genetic variation in domestic livestock herds.
- Clinical and sub-clinical enteric infections significantly reduce animal performance and negatively impact human food safety.
- Research on animal neurons may lead to engineered bionic replacements for individuals who have suffered the loss of a limb.
- Computer-based trade models of global trade liberalization indicated that while large wealthy farmers in developed countries might be adversely impacted, farmers in developing countries could be lifted out of poverty.
- While traditional commercial farmer demographic data do not explain dealer nor input brand loyalty, dealer and brand loyalty are intimately linked through other farmer behavioral and attitude factors.
- Corn breeders should select cultivars that produce starch granules with more channels.
- Maleic acid appears to be more effective than sulfuric acid in extracting xylose from corn stover.
- Light-emiting diode (LED) arrays use less energy than overhead lights to grow high-value crops in controlled environments.

Benefits:

- Cow-calf producers can extend the grazing period by 10 days and save $12 per cow per year with rotational grazing.
- Feeding ractopamine (Paylean™) can increase the efficiency of swine growth, increase producer profits, and reduce adverse environmental impacts.
- While arsenic is ubiquitous and can cause environmental problems and be toxic to plants, it holds promise as a treatment for leukemia and ovarian cancer.
- Release of disease-resistant apples has a positive impact for commercial and home fruit growers in the East and Midwest where apple scab and fireblight are serious problems.
- A non-fasted molt in layers with a diet fortified with omega-3 and omega-6 fatty acids can improve bird well-being without being detrimental to egg production.
- Spatial econometric analysis of yield monitor data for central Indiana showed a corn yield advantage of 5 to 20 bushels per acre from improved drainage control.
- Adding a cooling section to the bottom of a continuous-flow corn dryer could reduce drying costs by 10% and increase dryer capacity by 36%.
- High solid, low-temperature starch processing can reduce the water and energy requirements in an ethanol plant by 10%.
- Hydrolysis of oligosaccharides in a fixed bed reactor may reduce costs and enhance sugar fermentation in ethanol plants.

State Assessment of Accomplishments:

Research at Purdue University continues to address the needs of various diverse stakeholders representing the entire value-chain from input suppliers to farmers to processors to retailers to the final consumers at home and abroad. Research spans a very broad base, including, developing animal diets to reduce adverse environmental impacts from waste; evaluating new technologies as tools for agricultural competitiveness; evaluating contractual and structural options for producer competitive positioning; increasing the efficiency of plant growth, analyzing the economic and environmental implications of increased biofuels production, and helping farmers gain entrepreneurship skills in order to increase household income and diversity Indiana agriculture.

Resources:

In 2006, approximately $ 2.69 million of Federal formula funds and $ 21.68 million state funds plus 173.6 FTEs were invested in Goal 1. These are best estimates and are not presented as auditable numbers.

1A. Integrated and Sustainable Crop and Livestock Production Systems

Key Theme: Animal Genomics (1)

a. *Description:* Genetic selection of Holstein dairy cattle for high and low dairy form and correlated responses in milk production, longevity, overall health, and fertility is being studied. Initial matings in a planned selection experiment have been made and first heifer calves were born in May 2004. They were bred to selection line bulls beginning in August 2005. First females began to calve, producing second generation calves, in July, 2006. Female offspring subsequently will be mated with other bulls from the same line to develop two lines divergent for dairy form. Initial second generation matings were initiated in August 2005 and also continue. An attempt will be made to maintain approximately 60 cows per line in first and subsequent generations. In the first year, three bulls were selected and mated to cows in each group. These sires fit expectations with the lower Dairy Form STA bulls ranking better for most health and fertility traits. This will be part of a long term selection project. For the bulls selected for matings in 2005-2006, bulls in the low dairy form group averaged -1.9 STA for dairy form, compared to +3.42 STA for the high dairy form group. For this year,

daughters of bulls in the low dairy form group are expected to produce a modest 244 fewer pounds of milk per lactation, but are expected to stay in the herd longer, have less mastitis, and have a higher conception rate than daughters of bulls in the high dairy form group. Blood samples of foundation females have been collected and stored for future genetic analyses.

b. *Impact:* In the short term, results of the selection experiment will help determine whether cows with lower dairy form have advantages in longevity, disease resistance, and fertility. In the long term, results will allow dairy producers to determine how much selection emphasis to place on dairy form to achieve desired improvements in dairy form with other correlated traits such as cow fertility.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

Key Theme: Animal Production Efficiency (1)

a. *Description:* Feed is over one-half of the cost of production for an Indiana cow/calf producer with the largest part of feed being forages. If a producer could increase productivity of forages, it would be possible to decrease the cost of supplemental feeds. Studies conducted at two Purdue University Agricultural Research Centers have shown that by subdividing a pasture, livestock can graze one paddock while the other paddocks are re-growing. Forages will be available for a longer period within a given year. However, there are additional costs with paddock systems, e.g., fencing, water systems, and additional labor to move cattle between paddocks. The paddock system was tested at three sites. By using regression analysis, it was found that the paddock grazing system increased total grazing time by almost 10 days at Feldun, almost 53 days at SIPAC, and 19 days at Oldham when all other variables were held constant. At $1.19 per cow feed cost per day, each 10 additional days of grazing equates to a savings of almost $12 per cow every year. Hay production in a paddock system produced an additional 339 pounds of hay per acre. At $50 per ton, this adds $8.48 value per acre that can be used to reduce winter feed costs.

b. *Impact:* Beef cow-calf producers should review the economic feasibility of subdividing their pastures into paddocks. Increasing the number of paddocks increases annual grazing days and creates an opportunity to harvest a portion of the acreage as hay in the spring.

c. *Source of Federal Funding:* Hatch

d. *Scope of Impact:* Indiana

Key Theme: Animal Production Efficiency (2)

a. *Description:* A total of 1,920 pigs (equal barrows and gilts) were used in a 2 x 2 factorial, wean to finish experiment to determine the effects of diet (control versus low nutrient excretion) and manure pit management strategy (deep pit versus monthly pull plug) on excretion of nutrients and gaseous and particulate emissions. Pigs were housed in a 12-room environmental building with real-time monitoring of air quality, and quantitative manure collection from 24 pits (2/room). Each room contained 30 barrows (3 pens) and 30 gilts (3 pens), which were split-sex and phase fed to meet or exceed the nutrient requirements of pigs (NRC, 1998) at different stages of growth. Dietary treatments (control and low nutrient excretion) were maintained throughout the trial. Individual pig weights and pen feed consumption data were collected every two weeks. Four pigs from each pen

were scanned ultrasonically for determination of loin eye area and backfat thickness at two months of age and every four weeks thereafter during the study. At the end of the experiment, carcass data were collected at harvest on all pigs. Air temperature, relative humidity, total suspended particulates, ammonia, hydrogen sulfide, carbon dioxide, and methane concentrations were recorded every fourth week during the experiment. In addition, odor samples were collected at months 1, 3 and 5 of each wean-finish replicate in this experiment. A dynamic dilution venturi olfactometer was used, with trained panelists, to evaluate each bag sample of air for olfactometry. Odor and gaseous emission rates were calculated by multiplying air flow rates by the difference between inside and outside concentrations. Preliminary data indicate that pigs fed the low nutrient excretion diet grew faster than control fed pigs while consuming less feed, resulting in an improved feed efficiency throughout most phases of the trial. In addition, reductions in ammonia and hydrogen sulfide emissions have been observed when pigs were fed low nutrient excretion diets compared to control fed pigs.

b. *Impact:* Over the last 60 years the swine industry has undergone a shift from many farms producing a limited number of pigs to a small number of large confinement production facilities producing the majority of pigs. New regulatory pressures to meet water and air quality standards for CAFOs and NPDES permit regulations are placing additional economic and management burdens on pork producers, which may lead to further consolidation of the swine industry. Preliminary data from this project illustrate that feeding low nutrient excretion diets does not have to result in poor animal performance or carcass characteristics to yield reductions in gaseous compounds. Pigs fed the low nutrient excretion diets had improvements in average daily gain, feed efficiency, and were approximately 5.0 kg heavier at market than pigs fed control diets. Although backfat thickness was greater for low nutrient excretion fed pigs, there was no difference in percent carcass yield or total carcass value. These data may serve as a modeling tool for producers, extension educators, regulators, consultants, and legislators to plan environmentally sound pork production systems throughout the United States.

c. *Source of Federal Funds:* Hatch, USDA – National Research Initiative

d. *Scope of Impact:* United States

Key Theme: Animal Production Efficiency (3)

a. *Description:* Research has been conducted with larger commercial pork producers to evaluate the impact of alternative weaning and milk replacer strategies on pig growth from birth to market weight. A stochastic pig growth model which relates early pig growth including birth, weaning and nursery weight on pig compositional growth to market weight was developed with these data. Research has been conducted to refine the pig compositional model to take into account increasing dietary concentrations of ractopamine and increased market weights. Feeding of high energy diets including 3 to 5% fat further increases the carcass weight growth of pigs fed Paylean™.

b. *Impact:* The feeding of ractopamine (Paylean™) can substantially increase the efficiency of swine growth and reduces the environmental impact of pork production per pound of lean produced. The full benefits of feeding Paylean™ can only be achieved with improved feeding and marketing management. The optimal use of a constant level of Paylean™ and refined marketing strategy can result in increased profitability of $ 7 to $10 per year per head.

c. *Source of Federal Funds:* Hatch

d. Scope of Impact: United States

Key Theme: Animal Production Efficiency (4)

a. Description: The digestive tract of early-weaned pigs is still relatively immature at weaning. As a consequence, young pigs have insufficient pancreatic amylase and intestinal disaccharides activity along with insufficient hydrochloric acid secretion. Also, the abrupt change from a liquid diet of sow milk to a solid cereal based diet at weaning causes digestive upsets and can result in poor growth performance at this critical growth juncture and increases the susceptibility to intestinal infections from pathogenic organisms. A study utilizing 192 weanling pigs (avg. 19.1 days of age) was conducted with the pigs assigned to one of three dietary treatments:1) Basal control diet (NC); 2) Diet 1 + 55 ppm carbadox (CB); 3) Dietary acid (DA): diet 1 + 0.4% organic acid based blend (fumaric, lactate, citric, propionic, and benzoic acids) for days 0 to 14 followed by 0.2% inorganic acid based blend (phosphoric, fumaric, lactic, and citric acids) for days 14 to 28. Each dietary treatment was formulated with either limestone or calcium sulfate (reduced buffering capacity) as a calcium source to change the buffering capacity of the diet. Pigs were allotted based on genetics, sex, and initial body weight (Avg.= 5.9 kg) and were housed at 6 or 7 pigs/pen. Pen feed intake and individual body weight were recorded weekly. Treatments were fed throughout the trial in two phases: days 0-14 and days 14-28. During phase 1, pigs fed CB had greater average daily gain (P pigs fed DA being intermediate). During phase 2 and overall, pigs fed CB had greater average daily gain (P were 0.5 kg heavier at day 28 post-weaning than the control pigs). Alteration in dietary buffering capacity had its greatest influence on growth performance during phase 2 when the simplest diet was fed.

b. Impact: The use of diet acidification can work as a partial replacement for in-feed antibiotics in nursery pigs with typical U.S. diet formulations, recovering about 1/3 of the antibiotic response in nursery pigs. The buffering capacity of the diet does not seem to be a limiting factor in the dietary acids effectiveness as an antibiotic replacement. However, lowering the diets buffering capacity when simple corn-soybean meal diets are fed can improve feed efficiency. There continues to be a need for further research in finding alternatives to dietary antibiotics in nursery pig diets, with the need to evaluate combinations of alternative strategies as an antibiotic replacement.

c. Source of Federal Funds: Hatch,

d. Scope of Impact: United States

Key Theme: Plant Production Efficiency (1)

a. Description: Tomato farms in Indiana can be classified into five major groups based primarily on differences in row spacing, irrigation, tillage intensity, use of cover crops and hand-weeding. When herbicide use was excluded from the analyses, the conventional fresh market farms differed from organic farms primarily in the use of cover crops and hours spent hand-weeding fields. In contrast, conventional processing and organic farms had substantially different management systems even when herbicide use was excluded from the analyses. Each management system had problematic weed species that were related to management practices unique to that system. Weed densities after control practices were concluded for the season were high in all systems suggesting that increased attention should be given in tomatoes to reducing weed seed inputs.

b. *Impact:* The tomato project will help provide growers with information to select a weed management system that best suits their needs.

c. *Source of Federal Funds:* Hatch, USDA- Sustainable Agriculture Research and Education

d. *Scope of Impact:* Indiana

1B. Genetic Resource Development

Key Theme: Animal Genomics (1)

a. *Description:* Over the past twelve months this research was focused on improving porcine embryonic development after nuclear transfer. Experiments were performed where different cell types were used as nuclear donors. Three different cell types were compared: differentiated cells isolated from fetal fibroblasts, olfactory bulb progenitor cells and somatic stem cells isolated from porcine skin. The reconstructed oocytes were activated and cultured for seven days. By the end of the incubation period, the morula/blastocyst formation from skin stem cells was significantly higher than that from fetal fibroblasts. The formation of morulae and blastocysts per cleaved embryos was the highest in embryos reconstructed with olfactory bulb progenitor cells (23.5% versus 17.0% using skin stem cells and 11.6% using fibroblasts) implying that embryos produced using less differentiated cells may have higher developmental potential. Another line of experiments investigated the effects of different oocyte activation protocols on subsequent embryonic development. Three different activation protocols were compared: 1) electroporation, 2) electroporation followed by inhibition of protein synthesis, and 3) electroporation followed by protein kinase inhibition. All three activation protocols effectively down regulated the activity of crucial cell cycle-related regulatory proteins such as MPF and MAPK. After a seven-day culture in PZM-3 medium the combined treatments provided better development to the blastocyst stage, blastocyst formation was 45.6% in the electroporated group, while it was 64.9% in oocytes activated by electroporation plus protein kinase inhibition and 68.6% in the group where the oocytes were electroporated and then treated with a blocker of protein synthesis. The enhanced development was not the result of a decrease in programmed cell death since the proportion of cells showing early or late signs of apoptosis was similar after all treatments. These data indicate that the combined oocyte activation methods that target several points of the signaling pathway are able to trigger parthenogenetic embryonic development more effectively, at least to the blastocyst stage.

b. *Impact:* Nuclear transfer is the only method currently available for the production of transgenic livestock with targeted genetic modifications. Unfortunately, the efficiency of the technology is very low. This research suggests that nuclear transfer may be more effective when less differentiated cell types are used as nuclear donors during nuclear transfer. Laboratory results indicate that a high percentage of embryos can develop to the transferable stage if the oocytes are activated using the combined activation protocols following nuclear transfer.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Global

Key Theme: Animal Genomics (2)

a. *Description:* Two different disciplines, behavioral ecology and immunology, have been united in this study of genetic parentage and sexual selection. For example, genes of the major histocompatibility complex (MHC) have been implicated in vertebrate (human, mice, salmon) mate choice. Presumably, when MHC-dissimilar adults mate, their progeny are more diverse at MHC genes and can better fight infections of foreign pathogens. In some salamanders (axolotl), there is no diversity at key MHC genes and they are immunodeficient (cannot clear infections). Data on wild salamanders indicate they harbor substantial genetic variation at MHC genes and further, this variation is actively maintained via balancing selection. It remains to be determined whether or not salamanders choose mates on the basis of the variation at MHC genes.

b. *Impact:* This research is having a theoretical impact (population genetics theory) as well as a practical impact (conservation biology). By using DNA to study animals in their native environment, it is possible to obtain a more accurate picture of their natural history and diversity.

c. *Source of Federal Funds:* Hatch, National Science Foundation, USDA – National Research Initiative

d. *Scope of Impact:* United States

Key Theme: Apiculture (1)

a. *Description:* Following the discovery last year that stinging behavior showed a paternal effect, an assay to test whether candidate genes for stinging behavior show a paternal expression pattern was designed. Research on linkage mapping showed that the bee has the highest reported recombination rate for any higher eukaryote. The most relevant outcome of this year's efforts is the identification of candidate genes for QTL influencing foraging behavior and also for QTL influencing stinging behavior. Because of the high recombination rate of the honey bee, the field of genes, within 97% confidence intervals for each QTL, has been narrowed to about 40 genes. Genes likely to influence stinging behavior appear to be neuronal transcription factors, as well as genes that influence G protein-coupled signaling, such as an arrestin and a serotonin receptor.

b. *Impact:* Highly defensive Africanized honey bees now occur in the southern U.S. in states that are important sources of queen bees shipped to northern states. Commercial movement of bees is critical for pollination of many crops, for the honey industry and for hobbyists. The annual pollination value of crops by honey bees has been estimated to be 14 to 15 billion dollars. The search for genes responsible for stinging behavior of honey bees has been narrowed to small sets of genes at three genetic loci. This research will result in diagnostic tests that could be used to follow the spread of African versions of these genes and to evaluate their impact on bee behavior.

c. *Source of Federal Funds:* Hatch, National Science Foundation

d. *Scope of Impact:* United States

Key Theme: Biotechnology (1)

a. *Description:* Under both desiccation stress and well-watered conditions, a dynamic balance of both positive and negative regulators of stomatal aperture is necessary to ensure optimal CO2 uptake while limiting transpirational water loss from leaves of crop plants. Under favorable conditions this balance is achieved, in part, by negative regulation of stress responses to promote stomatal opening and to maximize uptake of CO2. This research focused on a hyper-osmotically sensitive mutant

plant, designated hos3-1, of Arabidopsis thaliana, and current results demonstrate that the disrupted gene is a direct or indirect negative regulator of the ABA-mediated stress responsive pathway. By genetic complementation of hos3 mutants the function of HOS3 is to inhibit ABA-mediated stress responses, including regulation of stomatal aperture, maintenance of primary root growth and inhibition of germination. Additionally, a very-long-chain fatty acid (VLCFA) pathway and its products act as regulatory components for several aspects of abiotic stress signaling and responses. Specifically, the defect in HOS3, which encodes an elongase-like protein, appears to confer ABA-hypersensitivity by disrupting VLCFA synthesis and reducing ceramide precursors.

b. *Impact:* This research has identified a novel locus that may exert a critical regulatory role in the control of stomatal aperture during periods of drought. Understanding the fundamental mechanism of stomatal control of water vapor loss from leaves may lead to the identification of molecular-genetic approaches to controlling water-use efficiency in crop plants.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Global

Key Theme: Biotechnology (2)

a. *Description:* The fern Pteris vittata (Pteridaceae), along with other members of the genus Pteris, is unique in its ability to tolerate and accumulate up to 1-2 percent of its tissue dry weight as arsenic, making it an excellent model system among plants, animal and microbes for the study of arsenic metabolism, accumulation and resistance mechanisms. In an effort to identify genes involved in arsenic metabolism and resistance in this fern, two yeast genes were cloned, named PvACR2 and PvACR3, from P. vittata that encode predicted proteins that are similar in sequence to the ACR2 and ACR3 proteins of Saccharomyces cereviseae, both of which are necessary for arsenic tolerance in yeast. The PvACR2 protein, like the yeast protein, has arsenate reductase activity in vitro and is able to complement the function of ACR2 in a yeast acr2 mutant. Interestingly, the active site of PvACR2 does not conform to the canonical HCX5R sequence that is present in all functionally characterized arsenate reductases and protein tyrosine phosphatases (PTP), including Arath/CDC25, the Arabidopsis thaliana homolog of PvACR2. The ACR3 protein of yeast is an integral membrane protein that functions as an arsenite effluxer, working in combination with ACR2 in yeast to prevent arsenic from accumulating to toxic levels within cells. The P. vittata PvACR3 complements the efflux function of ACR3 in a yeast acr3 mutant. The cloning of these two genes from P. vittata provides, for the first time, the genetic tools that are needed to understand how arsenic is transported and sequestered in the cell without cytotoxic effects.

b. *Impact:* Arsenic is a naturally occurring metalloid that is potentially toxic to most organisms. It is found in soils and ground water in many regions of the world, including the United States. In addition to becoming an increasing environmental problem, arsenic also has a history of use for medicinal purposes that date to the ancient Greeks. While no longer consumed to promote overall well being (as the arsenic-eaters did at the turn of the 19th century), arsenic toxicity is currently exploited in the treatment of leukemia and parasitic diseases. Arsenic trioxide, for example, has recently emerged as a drug of choice in treating acute promyelocytic leukemia and also holds promise for the treatment of ovarian cancer.

c. *Source of Federal Funds:* Hatch, Department Of Energy, National Institute of Health, National Science Foundation

d. Scope of Impact: Global

Key Theme: Plant Genomics (1)

a. Description: The maize Hm1 gene provides protection against a lethal leaf blight and ear mold disease caused by Cochliobolus carbonum race 1 (CCR1). Although it was the first disease resistance (R) gene to be cloned in plants, it remains a novelty because instead of participating in plant's recognition and response system, as most R genes do, Hm1 disarms the pathogen directly. It does so by encoding HCTR, whose function is to inactivate HC-toxin, an epoxide-containing cyclic tetrapeptide, which the pathogen needs to colonize maize. While CCR1 is strictly a pathogen of maize, orthologs of Hm1 as well as the HCTR activity are present widely in the grass family, suggesting an ancient origin and recruitment of this disease resistance trait in the grass lineage. But what could be its function in species that are not hosts of C. carbonum race 1? In collaboration with a USDA scientist in the Department of Agronomy, this question was addressed in barley using virus induced gene silencing (VIGS). The results clearly demonstrate that the nonhost resistance of barley to CCR1 is conferred by HCTR. Barley leaves in which expression of the Hm1 homologs was silenced became susceptible to infection by CCR1, but only if the pathogen was able to produce HC-toxin. A key implication of this finding is that HC-toxin has the ability to impair host defenses in all cereals. Since this fungal metabolite has been found to be a potent inhibitor of histone deacetylases (enzymes that regulate chromatin activity), one way to understand how HC-toxin induces susceptibility is by identifying maize genes whose transcription is specifically impacted by HC-toxin. Another implication of this study is that it demonstrates that nonhost resistance of barley is due to an active mechanism conferred by the Hm1 gene. Barley can no longer keep CCR1 (C. carbonum race 1) at bay if the function of its Hm1 homolog(s) is impaired. In fact, this is what happened in maize as well, but naturally. Like barley and all other grasses, maize was not a host to CCR1. However, certain inbred lines of maize that inherited null alleles of both hm1 and hm2 became susceptible to a heretofore unknown pathogen that was later named CCR1. It has been shown that Hm1 is a grass lineage specific gene which was recruited by a common ancestor of grasses after its divergence from lineages that led to lilies, onions and pine apple.

b. Impact: This work has important evolutionary implication for the survival and evolution of the grass lineage. Largely because of its ability to produce HC-toxin, C. carbonum race 1 is the most destructive pathogen of susceptible corn. It invades every part of the plant, killing it within a few days to weeks. A question that could be raised is: what would have happened if Hm1 was not recruited to disarm HC-toxin? Given the exceptional virulence that HC-toxin endows on C. carbonum race 1, it may not be an exaggeration to think that this pathogen or any other pathogen that had the ability to produce HC-toxin would have imposed tremendous pressure on the common grass ancestor to drive its extinction. Consequently, none of our major crop species would have evolved. So we owe a great deal to Hm1 that we have maize, rice, sugarcane and wheat to feed the humankind!

c. Source of Federal Funds: Hatch, USDA – National Research Initiative

d. Scope of Impact: Global

Key Ttheme: Plant Genomics (2)

a. Description: Polyamines (PAs) are ubiquitous, low molecular weight polycations which have been implicated in a number of physiological and developmental processes in various organisms. At

molecular levels, polyamines have been implicated to regulate DNA replication, transcription as well as enhance protein biosynthesis, possibly by stabilizing the DNA and the ribosomal complex, respectively. However, molecular mechanisms by which polyamines regulates these processes are not yet understood. Transgenic tomato lines over-expressing yeast SAM decarboxylase under a ripening specific promoter E8 were developed. Fruits of transgenic tomato SAMdc lines show enhanced polyamine accumulation, increase shelf life, improved juice attributes and increased levels of several metabolites. These transgenic tomato fruit provide an opportunity to study global effects of PAs at gene level and explore the possible regulatory modes for the observed physiological effects of enhanced polyamines during fruit development. We have developed a microarray from a normalized tomato fruit cDNA library containing more than 1000 unique Expressed Sequence Tags (ESTs) that are expressed in ripening fruits. This custom-made cDNA microarray was used to investigate effects of increased polyamines on the expression profiles of >1000 genes. Of the 710 (~67%) ESTs on microarray displaying quantifiable signal intensities during fruit ripening, 154 ESTs (22 %) were found to be differentially expressed between SAMdc transgenic and the control wild type fruits. The differentially expressed ESTs represented functional categories including cell wall, defense/stress response, DNA replication repair recombination, energy, ethylene response, metabolism, protein biosynthesis/degradation, signal transduction, transcription and transport. However, about 43 % of differentially regulated ESTs belonged to unclassified, unknown and novel gene categories. The elevated expression of signaling, defense and stress responsive genes in the transgenic fruit implicates Spd/Spm in regulating these pathways as transcriptional regulator. High resolution NMR methods were employed to generate a profile of metabolites in the wild-type and transgenic tomato fruit during fruit ripening. Distinct metabolites were found to accumulate (Glu, Gln, Asn, choline, and three unidentified compounds) or decrease (sucrose, glucose, Asp) in response to Spd/Spm accumulation in the transgenic versus the control (wild-type and azygous) fruits. Thus, pathways involved in the nitrogen and carbon assimilation seem preferentially activated in response to Spd/Spm accumulation in the transgenics. Taken together, these results, for the first time, show that Spd and Spm have profound effects on cellular metabolism, likely via regulating genes in the distinct biochemical pathways.

b. *Impact:* Hormones and growth regulators are signal molecules that regulate and modulate plant growth and development. These molecules are also crucial for many plant developmental processes including normal fruit induction, growth, and development and ripening. Exogenous applications and endogenous manipulation of these hormones and growth regulators have permitted intervention in fruit ripening processes to obtained optimum quality and extension of shelf life. In addition to the five classic hormones, namely, auxins, cytokinins, gibberellins, abscisic acids and ethylene, there are several other growth regulators that profoundly effect fruit ripening and quality attributes. Polyamines are reported to influence both fruit quality and shelf life. For the first time, research results indicate that polyamine influences a myriad of metabolites likely by influencing gene expression. These results will help develop interventions to impair deleterious processes in fruits and to improve both the nutritional and shelf life attributes of the ripened fruits.

c. *Source of Federal Funds:* Hatch, United States Agency for International Development

d. *Scope of Impact:* United States

Key Theme: Plant Germplasm (1)

a. *Description:* Seed of wheat lines 99608C1 and 011007A1 is being increased for release. Both lines have resistance to Fusarium head blight (FHB); 99608C1 has tolerance to yellow dwarf virus (YDV)

and 011007A1 has resistance gene Bdv3. INW0411, with excellent resistance to FHB, and INW0412, with moderate resistance to FHB are being widely grown in Indiana. The YDV resistance of INW0316, from intermediate wheatgrass, has been highly effective in tests throughout the mid-South and in Indiana, and its effectiveness was especially apparent in 2006 with widely-occurring severe YDV infection.

b. *Impact:* Fusarium head blight, yellow dwarf virus, and Hessian fly are three very important pathogen, virus, and insect pests of wheat in the eastern United States. Resistance in the host, wheat, has been the most effective and economical means of minimizing crop production and grain quality losses due to these pathogens and pests. Recent releases, the cultivars INW0411 and INW0412, have moderate resistance to FHB, cultivar INW0316 has resistance to YDV, and these cultivars are being widely grown in Indiana and surrounding regions.

c. *Source of Federal Funds:* Hatch, Initiative for Future Agriculture & Food Systems, United States Wheat and Barley Scab Initiative

d. Scope of Impact: Eastern United States

Key Theme: Plant Germplasm (2)

a. *Description:* Aldehydes are intermediates in a variety of biochemical pathways including those involved in the metabolism of carbohydrates, vitamins, steroids, amino acids, hormones, and lipids. In plants, they are also synthesized in response to environmental stresses such as salinity, cold, and heat shock or as flavors and aromas in fruits and flowers. Phenylacetaldehyde (PHA), along with 2-phenylethanol and its acetate ester, are important scent compounds in numerous flowers, including petunias and roses. We have isolated and characterized Petunia hybrida phenylacetaldehyde synthase (PAAS), which catalyzes the formation of phenylacetaldehyde (PHA). PAAS is a cytosolic homotetrameric enzyme that belongs to group II PLP-dependent amino acid decarboxylases and shares extensive amino acid identity (~ 65%) with plant L-tyrosine/L-dopa and L-tryptophan decarboxylases. It displays a strict specificity toward phenylalanine with an apparent Km value of 1.2 mM. PAAS is a bifunctional enzyme that catalyzes the unprecedented efficient coupling of phenylalanine decarboxylation to oxidation, generating phenylacetaldehyde, CO2, ammonia, and hydrogen peroxide in stoichiometric amounts. Phenylpropenes such as chavicol, anol, eugenol and isoeugenol are produced by plants as defense against animals and microorganisms and as floral attractants of pollinators. Moreover, humans have used phenylpropenes since antiquity for food preservation and flavoring and as medicinal agents. Previous research suggested that the phenylpropenes are synthesized in plants from substituted phenylpropanols, although the identity of the enzymes and the nature of the reaction mechanism involved in this transformation have remained obscure. We found that glandular trichomes of sweet basil (Ocimum basilicum), which are known to synthesize and accumulate large amounts of such phenylpropenes, possess an enzyme that can use coniferyl acetate and NADPH to form eugenol. Petunia (Petunia hybrida L. Mitchel) flowers, which emit large amounts of isoeugenol, possess an enzyme homologous to the basil eugenol-forming enzyme that also uses coniferyl acetate and NADPH to catalyze the formation of isoeugenol. The basil and petunia phenylpropene-forming enzymes belong to a structural family of NADPH-dependent reductases that also includes isoflavone reductase, pinoresinol-lariciresinol reducatase, and phenylcoumaran benzylic ether reductase.

b. *Impact:* Volatile compounds released from leaves, flowers, and fruits play important roles in plant life as attractants, repellents, and signal molecules. While volatile signaling, repelling or attracting during pathogen or herbivore attack is important for plant survival, floral scent plays a vital role in the plant reproductive cycle by attracting pollinators to flowers. However, how plants produce volatile compounds and what molecular mechanisms control their accumulation and release present significant questions in plant biology, with both basic and practical aspects, that remain unsolved. This research not only provides the knowledge for engineering plants with improved scent quality, but will also result in new insights into the regulation of floral scent production in higher plants.

c. *Source of Federal Funds:* Hatch, USDA – National Research Initiative

d. *Scope of Impact:* Global

1C. Plant Stress Management

Key Theme: Ornamental/Green Agriculture (1)

a. *Description:* Creeping bentgrass and Kentucky bluegrass are the two most popular cool-season turfgrasses used on golf courses, sports fields, and home lawns. Growth, physiological and anatomical responses of 5 creeping bentgrass cultivars were studied to different depths after 21 days of waterlogging. Waterlogging reduced turf quality, root dry weight, root water soluble carbohydrate content, and root soluble protein content. Turf quality and chlorophyll content decreased with increasing water levels from 15- to 1- cm below the soil surface. The formation of aerenchyma was enhanced when water levels were 15- and 5-cm below the soil surface. Mitochondrial swelling occurred when water level was 1 cm below the soil surface. Cultivars of G-6 and L-93 had better turf quality than A-4, Penncross, and Pennlinks under waterlogging conditions. Ten Kentucky bluegrass cultivars were subjected to 30 days of waterlogging. Significant differences in chlorophyll content, root water soluble carbohydrate content, root electrolyte leakage, and root oxidase activity were observed among the cultivars exposed to waterlogging. Moonlight was the most tolerant cultivar, followed by Serene and Limousine, particularly when grasses were exposed to short-term waterlogging. Kenblue and Eagleton were the least tolerant cultivars. Unique, Awesome, Champagne, Julia, and Midnight II ranked in the middle group. These results suggest that declines in turf quality under waterlogging were closely associated with growth and metabolic responses of turfgrass. Even partial waterlogging could substantially affect turfgrass growth and physiological activities.

b. *Impact:* Mitochondria stability, root carbohydrate content and electrolyte leakage are important indicators for waterlogging tolerance. Knowing the variations in waterlogging tolerance among creeping bentgrass and Kentucky bluegrasses cultivars could potentially be used for enhancing turfgrass management.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

Key Theme: Plant Germplasm (1)

a. *Description:* Near-isogenic lines (NILs) with modifications in lignin composition (brown midrib1 (bm1), bm2, bm3, and bm4) were combined with near-isogenic lines (in the same background) in

which anthocyanin levels varied due to two mutations: Booster (B) and Pl (Purple plant). Thus, lines in which both lignin and anthocyanin production varied were created. One mutant was created in which multiple bm mutations were combined: bm1, bm2, B, Pl. Attempts to create a bm2, bm4, B, Pl mutant were unsuccessful. The lignin composition appears to be minimally affected by anthocyanin production in the plant, based on pyrolysis-gas chromatography-mass spectrometry analyses. The accumulation of anthocyanins may be of help to the plants at high altitudes (high levels of UV radiation) or cool climates (increase in plant temperature).

b. *Impact:* The overproduction of compounds that absorb UV radiation and act like plant sunscreens appears to reduce the ability of the corn plant to produce seed. Based on the data produced so far the overproduction of anthocyanins as a strategy to protect the plant from UV radiation appears to have a negative impact on the fertility of the plant. Many of these plants do not produce silks at all, or the silks are desiccated when they appear. If the negative impacts of changes in lignin composition are generally limited, development of maize with altered cell wall modification could result in enhanced nutritional quality of forage and silage maize without negative impacts on yield. Another application could be the use of maize stover as a source of renewable energy or green chemical feedstocks.

c. *Source of Federal Funds:* Hatch, National Science Foundation

d. *Scope of Impact:* Corn Belt

Key Theme: Plant Germplasm (2)

a. *Description:* During 2005-2006 three new cultivars were released and licensed: a scab-resistant apple from the Cooperative Purdue-Rutgers-Illinois (PRI) program (Co-op 39=CrimsonCrispTM (2006)) ; a blight tolerant pears from the Purdue pear breeding program (H2-168=AmbrosiaTM), and a late-bolting arugula from the Purdue arugula program (AdagioTM). All apples contain the Vf gene which confers field immunity to apple scab incited by Venturia inaequalis which was derived from Malus floribunda 821.

b. *Impact:* The release of disease-resistant apple and pear is having a positive impact for commercial fruit growers and home gardeners, especially in the fruit areas of the East and Midwest where apple scab and fireblight are a serious problem. The new selections will be extremely useful for growers interested in organic or integrated production. We expect the greatest impact may be on small growers who deal in local markets, although CrimsonCrisp in particular has great promise in the commercial market. Efforts are underway to market these cultivars worldwide and this apple is now being widely appreciated in Western Italy.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States and Europe

Key Theme: Plant Health (1)

a. *Description:* In a field experiment, presence or absence of corn residue on the soil surface had no effect on the intensity of Fusarium head blight symptoms on wheat, nor on frequency of visibly damaged kernels (VDK), on frequency of infection of visibly sound kernels by Gibberella zeae, or on level of DON in the flour. Inoculum in the Corn Belt may be sufficiently abundant and widespread to negate local field effects of corn residue. A foliar fungicide had no effect, except to reduce the

frequency of visibly scabby kernels (VDK). Assessment of airborne spores of Gibberella zeae revealed considerable day-to-day variation in spore numbers. Spores were detected throughout the sampling period, which began approximately one week before onset of flowering of wheat, and continued for 3 weeks. Cultivar Patterson developed substantially more head blight than cultivars Hopewell and Truman, which began flowering 3 to 4 days later than Patterson. Airborne spores of G. zeae were abundant on the second day of flowering of Patterson, before the other two cultivars had begun to flower, which may account for the greater disease intensity on Patterson. There were weak, but significant correlations between head blight intensity in the field and frequency of VDK or infection of apparently sound kernels. At very low intensities of head blight (less than 1%), VDK ranged from 0 to 4% and infection of apparently sound kernels ranged from 28 to 68%. There was no correlation between level of DON and intensity of head blight, frequency of VDK, or frequency of infection of apparently sound kernels. Eleven wheat lines were evaluated for head blight development in cultivar trials at five locations throughout Indiana. There was little or no head blight at four locations, but moderate disease at the west-central location. Lines differed in incidence of head blight at three locations, frequency of VDK at three locations, and DON content at three locations. Except for one line at one location, DON levels were less than 2 ppm. The correlation between head blight intensity and DON level was significant at only two locations, but even there the association was weak. The same level of DON was found over a range of head blight intensities. At the location with the greatest intensity of head blight, 9 of the 11 lines headed on 10 or 11 May, and among these, incidence of head blight ranged from 5.4 to 11%, suggesting that differences reflected genetic resistance rather than simply escape from infection. In fungicide trials at two locations, treatments provided only modest control of Stagonospora leaf blotch. Many treatments reduced the severity of head blight, but only a few reduced incidence of head blight, suggesting that fungicides may work better to retard spread of the fungus within the spike after initial infection than to reduce the frequency of initial infection. A few treatments reduced the frequency of VDK, but none reduced the frequency of infection of visibly sound kernels. A few treatments reduced the level of DON, particularly at the southern Indiana location where DON levels in the untreated grain was lower than at the central Indiana location.

b. *Impact:* This research contributed data for the development of a weather-based, risk model for Fusarium head blight of wheat. This model is deployed on the Web, for all states where head blight is a threat. The fungicide trials generate data that can be used to support an application to the U.S. Environmental Protection Agency for a Section 18 registration of Folicur fungicide for use against head blight. This research also generates data to support registration of experimental fungicides. The studies also demonstrate that head blight intensity is not a reliable predictor of DON toxin in grain, meaning that plant breeders may need to select for resistance to toxin accumulation directly, in addition to resistance to head blight.

c. *Source of Federal Funds:* Hatch, United States Wheat and Barley Scab Initiative

d. *Scope of Impact:* Eastern Corn Belt

Key Theme: Plant Production Efficiency (1)

a. *Description:* Soybean growers are faced with new crop and pest management technologies, new agronomic traits, and an ever changing pest complex. Two new pests--the soybean aphid and the soybean rust fungus --may combine to form a potentially devastating pest complex, both of which require management with pesticides. To manage soybean rust, field research indicates that row spacing has no effect on spray canopy penetration at any application timing and that damage from

sprayer wheel tracks will significantly reduce yield once the soybean crop enters the reproductive growth stage. At the whole-field level, this damage will depend on sprayer boom width. Results suggest that growers should apply fungicides in at least 15 gallons per acre of carrier.

b. *Impact:* Indiana growers do not need to greatly modify their production practices to manage soybean rust.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

1D. Animal Disease, Health, and Well-Being

Key Theme: Animal Genomics (1)

a. *Description:* Genetic variation in post-thaw semen fertility is being investigated. A semen sample is collected from boars as they enter semen collection centers, prior to the populations being subjected to selection based on reproductive performance. Semen is evaluated for sperm concretion, motility and abnormalities prior to freezing. After freezing, a post-thaw analysis of motility and abnormalities is reassessed. Preliminary data analysis has identified significant sources of variation for boar location, boar line and boar within line.

b. *Impact:* The United States is building a reserve of genetic material to preserve the genetic variation of our domestic livestock resources. The germplasm preservation and utilization effort is needed to insure the long-term viability of our animal agricultural industries. Current efforts of germplasm preservation of domestic livestock are utilizing cryopreservation of semen. Unlike human, ovine and bovine semen, porcine semen does not cryopreserve well. There is a large amount of variation among individual boars in post-thaw motility and sperm abnormalities that lead to reduced, or no, fertility. Differences among families and lines in freezability need to be taken into consideration as populations are sampled to insure that the full range of genetic variability of all traits is preserved. Information derived from this project will contribute to designing efficacious sampling strategies to insure a representative sample of livestock populations.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

Key Theme: Animal Health (1)

a. *Description:* Recent basic research has expanded our knowledge of the importance of interactions between intestinal microorganisms; and interactions between the intestinal microbiota, intestinal epithelium and mucosal immune system, which are involved in maintaining animal health and wellbeing. A collaborative group of researchers has investigated these interactions, the effect of stressors on these interactions, and dietary and management approaches to manipulate these systems to enhance animal health and wellbeing. Probiotics and prebiotics, short term and long term heat stress and food withdrawal increase variability in microbial community structure *in vivo* and attachment of salmonella to ileal tissues in an *in vitro* ileal challenge model, suggesting diet additions and environmental stressors reduce the ability of intestinal epithelial tissues to resist colonization. Transportation stress alters immune function in pigs and lairage may mitigate some of these

responses. Transportation also alters intestinal microbial community structure and these alterations are influenced by lairage. Lairage increases variation in microbial community structure, initially in jejunal contents and subsequently in cecal contents. This increase in variability is consistent with the concept that disruption of the intestinal microbiota decreases intestinal resistance to infection. Replacing soybean meal with coconut meal had no influence on carriage of salmonella in broilers orally challenged with salmonella. However, salmonella did not significantly colonize pasture-raised broilers over 3 days, but did colonize the ceca of intensively raised broilers. These data indicate that dietary, environmental and stress factors influence the ability of livestock to respond to pathogen exposure and to resist pathogen colonization.

b. *Impact:* Clinical and sub-clinical enteric infections in livestock significantly reduce animal performance and negatively impact human food safety. Interactions between the intestinal microbiota, the intestinal lining and the intestinal immune system are important in maintaining health of livestock. Diet and environmental/management stressors (feed withdrawal, heat stress, transportation) negatively influence the immune system and disrupt the intestinal microbiota. Fasting and heat stress significantly increase attachment of salmonella to the intestinal lining in *in vitro* studies.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

Key Theme: Animal Health (2)

a. *Description:* The nervous system of animals is made up of specialized cells called neurons that are able to transmit and process information. These cells have long protrusions that extend toward and contact other neurons to form networks. These networks are similar to the circuit boards that are found in modern computer systems. If the neurons (or circuits) are not connected together in just the right way, the nervous system (computer) will not function properly. In the case of computers, people and machines are responsible for hooking up the circuitry correctly. But in the case of the nervous system, the neurons have to search out their own connections! But how do the neurons know which partners to hook up with and which to avoid? Neurons produce proteins called receptors that are displayed on the surface of their long extensions. These receptors sense other proteins in their local environment and grow toward sources of attractive proteins and away from sources of repulsive proteins. However, not all neurons produce the same receptors, so different neurons respond differently to the same environmental proteins. Once a neuron extension has made it to the proper place it has to pick a partner, from a sea of potential partners, to form a special connection called a synapse that allows information to flow from one neuron to the next. The process of a neuron picking a partner is known as target selection. If these processes fail to proceed correctly, developmental diseases such as Down Syndrome result. The receptor for a Down Syndrome cell adhesion molecule, Dscam for short, appears to help neurons find their correct targets. But, how can a single receptor help all neurons select targets? It turns out that the gene that is responsible for the production of the Dscam receptor is able to make many different forms of Dscam through a process called differential splicing. An appealing possibility is that in different neurons, the Dscam gene may make different forms of Dscam receptor. The neurons then use the specific forms that they make to find their targets, much like a postman uses the address on letters to find the correct mailbox. Using Dscam as an inroad to connection specificity, experimental systems have been initiated to search for those genes that function with Dscam to wire up the nervous system. These systems employ genetic strategies

and emerging technologies in the field of mass spectrometry. A candidate protein called Activated Cdc42 Kinase has been identified that appears to function with Dscam..

b. *Impact:* The impact of this research may be far reaching. Its focus is on the genes and events that control the formation of the nervous system. Once understood, it may be possible to develop new tools to diagnose and prevent developmental diseases of the nervous system for which there sadly is no current cure. This research will also allow the creation of new methods to repair injuries to the nervous system such as damage caused by physical contact or by stroke. Finally, this research will open doors to methods that will enable us to remodel the nervous system in a defined way and allow for the development of neuroelectronic interfaces. These interfaces will enable the fusion of man and machine in a precisely defined manner to allow those that have suffered loss of a limb, for example, to have functionalities restored by substitution with engineered bionic replacements.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Global

Key Theme: Animal Production Efficiency (1)

a. *Description:* Commercial laying hens are susceptible to osteoporosis due to their high sustained rates of egg production. Induced molting is currently an integral part of the replacement programs used on table egg production farms in the United States. However, existing molting induction procedures (by light manipulation and feed removal) have become increasingly criticized on animal well-being grounds and lead to bone mineralization loss during the molt. Research has been directed toward finding alternative methods for molt induction that do not require complete removal of feed. This research investigated changes in bone integrity and circulating concentrations of insulin-like growth factor-I (IGF-I) of hens subjected to two distinct molting regimens and fed pre- and post-molt diets either high in omega-3 (n3) or omega-6 (n6) fatty acids. A non-fasted molt compared to fasted molt was less detrimental to bone mineralization and the dietary n6/n3 fatty acid ratios in the pre- and post-molt diets had little effect on the decline of skeletal integrity during molt. This study is the first description regarding circulating IGF-I and its mRNA IGF-I gene expression in the liver of hens during molt and leading into the second cycle of egg laying. The IGF-I levels in laying hens were markedly sensitive to nutritional status. Molt had a profound effect on circulating concentrations of IGF-I and hepatic IGF-I mRNA expression. Regardless of molting regimen, whether it was induced by fasting or nutrient restriction (wheat middling based diet), the IGF-I response was the same with reduced plasma concentrations on day 2 and an overshooting phenomenon by day 13 of molt that was sustained through 43-day post-molt as compared to controls.

b. *Impact:* As a result of this research, the majority of U. S. egg producers have switched from a fasting to a non-fasting molting regimen which has improved animal well-being without being detrimental to egg production.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

Key Theme: Animal Production Efficiency (2)

a. *Description:* The first replicate of the foundation populations for the Soy Allergen selections lines has farrowed and the pigs selected for the first generation. Selection was based on high and low allergenic response to soy and peanut protein evaluated with an intradermal injection after challenging the pigs with a 28% soybean meal nursery diet for three weeks post-weaning. Sows are being rebred to generate offspring for the second replicate. Selection is planned to continue for five generations.

b. *Impact:* Pigs have an allergic response to soybean proteins when they receive their first post-weaning diet containing soybean proteins. This response results in restricted nutrient absorption, reduced intestinal barrier function, and increased susceptibility to intestinal pathogens. The expression of clinical enteric disease follows the pigs transitory hypersensitive to soybean allergens. If genetic methods to reduce pigs' allergenic response to soybean meal can be developed, there would be a reduced need to feed antimicrobials to control enteric diseases. Currently, pigs show a great deal of variation in their immune response to soybean allergens. There is also cross-reactivity between peanut and soy allergens in pigs. Therefore, biomedical researchers can use pigs developed by this project to study peanut allergy with application to humans.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

1E. Farm Business Management, Economics, and Marketing

Key Theme: Agricultural Competitiveness (1)

a. *Description:* The prospect of a global trade agreement under the auspices of the Doha Development Agenda has generated widespread interest in its likely poverty impacts. Many developing countries have high expectations for poverty reduction following the proposed elimination of subsidies for farm production as well as cuts in merchandise tariffs in the industrialized countries. However, studies to date of this issue have been either highly aggregated, global evaluations, or country-specific case studies. This research addressed the vast gap between these two groups by reporting on a cross-country evaluation of the poverty impacts of a successful prospective Doha Development Agenda. To accomplish this, previously published methodology, which links results from a global trade model with a country-specific micro-simulation framework, was combined with household survey data from fifteen low-income countries. Overall, reductions in agricultural subsidies are likely to increase poverty across most of the developing countries because of their impact on food prices for the poor. Tariff reductions in developing countries, taken as a group, tend to enhance the poverty outcome of the low-income countries. Because the prospective Doha reform includes relatively small tariff cuts among developing countries, deepening these commitments to reform would make it more poverty friendly. Of course, these poverty reductions will not occur in the absence of WTO reforms, and these are presently stymied by an impasse between the EU and the USA on agricultural trade policies.

b. *Impact:* Agricultural trade policies of rich countries are the battleground on which the future of the WTO's troubled Doha Round will be determined. Subject to widespread criticism, they nonetheless appear to be almost immune to serious reform, and one of their most common defenses is that they protect poor farmers. Analysis from this project rejects this claim. The analysis conducted here uses detailed data on farm incomes to show that major commodity programs are highly regressive in the USA, and that the only serious losses under trade reform are among large, wealthy, farmers in a few

heavily protected sub-sectors, e.g., dairy, sugar, cotton, and rice. Compensation of these farmers is feasible, and, if appropriately targeted, would not be prohibitive in cost. In contrast, analysis using household data from fifteen developing countries indicates that reforming rich countries agricultural trade policies would lift large numbers of developing country farm households out of poverty. In the majority of cases these gains are not outweighed by the poverty-increasing effects of higher food prices among other households. Agricultural reforms that appear feasible, even under an ambitious Doha Round, achieve only a fraction of the benefits for developing countries that full liberalization promises, but protects US large farms from most of the rigors of adjustment.

c. *Source of Federal Funds:* Hatch, United States Environmental Protection Agency, USDA - National Research Initiative

d. *Scope of Impact:* Global

Key Theme: Agricultural Competitiveness (2)

a. *Description:* An appropriate mix of government and private sanctions is required to optimize the deterrence of cartel formation and recidivism. Published economic studies and judicial decisions that contain 1,040 quantitative estimates of overcharges of hard-core cartels were surveyed. The primary finding is that the median long-run overcharge for all types of cartels over all time periods is 18.8% for domestic cartels and 31.0% for international cartels. The mean overcharge for all successful cartels is 43.4%. Convicted cartels are on average as equally effective at raising prices as unpunished cartels. These findings suggest that optimal deterrence requires that monetary penalties ought to be increased. Second, a formal meta-regression analysis confirmed the previous survey. The analysis found that duration, legal environment, and organizational characteristics of cartels explain variation in overcharge rates to a greater extent than the type of publication or the method of calculation. Overcharges tend to be significantly higher for durable international cartels. Secular decline is observed as antitrust enforcement regimes have stiffened. Third, a case study of the vitamins cartel confirmed the inadequacy of antitrust sanctions to deter recidivism. Evidence is presented that these 16 interrelated cartels were the largest discovered international price-fixing schemes of the late 20th century in terms of affected commerce and direct overcharges. There is little question that the convicted members of the vitamins cartels were in absolute monetary terms the most heavily sanctioned defendants in the history of antitrust law. Yet, it is equally non-controvertible that the impressive corporate monetary sanctions imposed worldwide were inadequate to deter recidivism. Fourth, the antitrust fines and private penalties imposed on the participants of 260 international cartels discovered during 1990-2005, using four indicators of enforcement effectiveness, were assessed. First, the United States is almost always the first to investigate and sanction international cartels, and its investigations are about seven times faster than EU probes. Second, U.S. investigations were more likely to be kept confidential than those in Europe, but the gap has nearly disappeared since 2000. Third, median government antitrust fines average less than 10% of affected commerce, but rise to about 35% in the case of multi-continental conspiracies. Civil settlements in jurisdictions where they are permitted are typically 6 to 12% of sales. Canadian and U.S. fines and settlements imposed higher penalties than other jurisdictions.

b. *Impact:* Based on these research findings, presentations before antitrust authorities in the United States, European Union, Canada, and the Netherlands, have stressed that current cartel fining standards are sub-optimal. Subsequently, the European Commission has altered its fining guidelines.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Global

Key Theme: Agricultural Profitability (1)

a. *Description:* Data from a 2003 survey of U.S. commercial agricultural producers was used to investigate brand and dealer loyalty for production inputs. Key findings include 1) demographic variables are poor at explaining loyalty to brands; 2) loyalty to a dealer is an important predictor of brand loyalty; and 3) factors that affect dealer loyalty affect brand loyalty. This study showed that dealer loyalty and brand loyalty are intimately related, and therefore manufacturers must carefully consider dealer branding as they develop product branding strategies.

b. *Impact:* As dealers and manufacturers develop their marketing strategies, an understanding of the relationship between dealer brands and product/manufacturer brands is important.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

Key Theme: Precision Agriculture (1)

a. *Description:* Previous research on the economics of site-specific crop management indicated that higher input and crop prices encourage adoption of precision agricultural practices. Re-analysis of data from Indiana site-specific fertilizer studies in the 1990s suggested that while the higher fertilizer and corn prices in 2006 increase the profitability of site-specific management, these prices do not change the overall results of those earlier studies. Variable rate application of lime is even more profitable than it was in the 1990s. Studies show that variable rate application of phosphate and potash is sometimes profitable, depending on soil test levels, information costs, variable rate application fees and crop response. The profitability of variable rate application of nitrogen varies widely from year to year because of the temporal variability of nitrogen response. Research on knowledge intensive crop management practices suggests that controlled drainage could provide enough yield advantage to cover the cost of labor and of installing water management structures.

b. *Impact:* Spatial econometric analysis of yield monitor data from central Indiana fields in 2005 showed a corn yield advantage of controlled drainage of 5 to 20 bushels per acre. The yield advantage was slightly higher in the lower portions of the topography and negligible in the upper portions of the topography. With the 2005 level of yield advantage, the annual benefit of controlled drainage ranged from $11.45 to $14.19 per acre without government subsidies.

c. *Source of Federal Funds:* Hatch, USDA - Sustainable Agriculture Research & Education

d. *Scope of Impact:* Corn Belt

1F. Value-Added

Key Theme: Adding Value to New and Old Agricultural Products (1)

a. *Description:* The primary goals of this project were to: (1) quantify the benefits of tempering on single kernel moisture content and stress crack development of corn using data collected in a small prototype continuous-flow dryeration unit, (2) use the experimental results to modify and validate an existing computer simulation model in order to (3) scale-up and optimize the continuous-flow dryeration system for a typical on-farm and elevator application, quantify energy savings and develop recommendations for future implementation. The experimental tempering results indicated that tempering reduced stress cracks up to 100% and moisture variability by 55 to 73% with the greatest reduction observed during the first four hours. Commercially, available hopper bins could be modified to incorporate a cooling section in the bottom and a tempering section in the top portion of the bin. Once validated, the cooler model was used to predict the moisture removal for a typical on-farm and elevator continuous-flow dryeration system. The results indicated that the optimum elevator and on-farm applications removed up to 1.9 points of moisture from a hot grain moisture content of 17%. It was also determined that the continuous-flow dryeration system could reduce drying costs by up to 10.3% while increasing drying capacity by up to 36%.

b. *Impact*: Based on the results of this research, continuous-flow dryeration systems could be designed and built to meet the growing needs of producers and elevator managers to increase drying capacity of existing systems while maintaining grain quality, and reducing drying costs and energy consumption.

c. *Source of Federal Funds:* Hatch, USDA-National Research Initiative, Midwest Advanced Food Manufacturing Alliance, North Central Region Integrated Pest Management, Small Business Initiative Research

d. *Scope of Impact:* Corn Belt

Key Theme: Biobased Products (1)

a. *Description:* Approximately 30 different procedures for removing channel proteins were investigated. Two were determined to be best: (1) extraction with a 0.1% solution of the detergent SOS containing 0.1% 2-mercaptoethanol which did not extract granule matrix proteins and (2) hydrolysis with a protease, either thermolysin (contains some amylase activity) or proteinase K (devoid of amylase activity. It was also determined that commercial corn starch already has some of the protein removed from the channels because industrial steepwater contains proteolytic activity from microorganisms present in it. So samples with the proteins intact must be prepared in the laboratory using a microbe-free dilute solution of sulfurous acid. Channels of corn starch granules are lined with proteins and lipids. When they are subjected to crosslinking, three types of crosslinking could occur: protein-protein, protein-starch, starch-starch. To determine which of these may be occurring and the effects on crosslinking of the removal of channel proteins, normal and waxy corn starches were treated with a proteinase before and after crosslinking and the properties of the products were compared with those of controls. Three reaction sequences, two crosslinking reagents, and two types of reaction media were used. In all cases, the trends were generally the same, with relative degrees of crosslinking indicated to be proteinase treatment after crosslinking, crosslinking alone, and proteinase treatment before crosslinking. Crosslinking involves protein molecules and is less effective when the protein is removed. Since the effect is more pronounced in normal corn starch than in waxy corn starch, protein-amylose or GBSS-starch crossslinks may play a role. The finding that 0.1% SOS + 0.1% 2-ME solubilized the channel proteins without extracting the proteins in the granule matrix enabled isolation of the channel proteins for identification.

b. *Impact:* The corn starch industry, which consumes more than 200 million tons of corn annually, prepares modified starch for use by other industries without completely understanding the effects of its granular nature on modification reactions. While the hypothesis was that removal of the proteins lining corn starch channels would result in more effective crosslinking, it was found that the opposite was true. Two benefits from application of this knowledge are possible: (1) Channel proteins are important in the crosslinking modification. Hence, corn breeders should look for cultivars that produce starch granules with more channels, and (2) Modifications of the commercial isolation process should be explored.

c. *Source of Federal Funds:* Hatch, USDA-National Research Initiative

d. *Scope of Impact:* United States

Key Theme: Biobased Products (2)

a. *Description:* Maize starch mutants were planted in the greenhouse for crossing studies. The goal is to produce an array of genotypes in which the starch biosynthetic pathway is impacted, thus generating mutant starches with altered molecular structure and functions. A comprehensive system that extracts, isolates, and characterizes starch branching enzymes, starch debranching enzymes, and starch synthases has been established. This system includes a preparative electrophoresis system by which enzyme isoforms can be isolated with high resolution, a high throughput microplate enzyme identification system to identify enzyme activities, and a native-PAGE-zymogram system to compare enzyme activity profiles from different maize genotypes. Using the capillary rheometer as the model system of high shear controlling, synergistic effect was found among the shear rate and alpha-amylase during the degradation of starch with 30% moisture content. It was evident that, first, high shear rate allows for a significantly greater starch degradation at low temperatures (e.g., 70 degree C), and second, the glucose yield after amyloglucosidase treatment may be substantially improved by high shear treatment. This finding is important since high-solid, low-temperature starch conversion can be used in an ethanol or corn refining plant to reduce the energy required for heating water. In addition, low-temperature processing may improve the quality of co-products from corn meal.

b. *Impact:* High-solid, low-temperature starch processing is very important, since it proves the concept of reducing the amount of water needed to cook starch, and minimizing the energy needed to heat water. An industrial application of this concept will possibly reduce the energy consumption of an ethanol plant by 10%. In addition, it may provide an approach to improve the quality of co-product from corn meal residuals which is important to the livestock sector.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

Key Theme: Biofuels (1)

a. *Description:* The U.S. ethanol industry has benefited from government subsidies that began in 1978. The current federal subsidy is 51 cents per gallon of ethanol. This subsidy level was established when production of ethanol was low and the crude oil price was less than $30 per barrel. In 2006, about 5 billion gallons of ethanol were produced and crude oil was about $60 per barrel. With this level of ethanol production, the subsidy cost taxpayers $2.5 billion in 2006. With high crude oil prices and the fixed subsidy, ethanol is highly profitable, and production capacity has been growing very

rapidly. It is expected to reach 8 billion gallons in 2007. In this research, several versions of a variable ethanol subsidy were modeled. One variant had the subsidy varying with ethanol or gasoline prices and corn prices. Another varied the ethanol price as a function of crude oil price alone. With crude oil at $60 per barrel and current ethanol production costs, ethanol plants can afford to pay up to $5 per bushel of corn. Thus, the fixed subsidy puts strong upward pressure on corn prices as occurred in late 2006. A variable subsidy could reduce substantially this pressure on corn prices because it would eliminate the subsidy when crude oil prices are high, but still provide a safety net for ethanol producers when crude oil is lower priced.

b. *Impact:* The variable ethanol subsidy is now being considered in policy circles in Washington and by farm groups around the country. Senator Richard Lugar has introduced legislation containing a version of the variable ethanol subsidy. This legislation will be considered by the next Congress. If a variable subsidy is adopted, it could retain the incentive to produce ethanol from corn, but reduce the incentive when crude oil price are high. There will be little incentive to invest in cellulosic ethanol, a less certain technology, so long as the incentives for corn ethanol remain strong. Thus, the variable subsidy could help direct some investment towards newer technologies.

c. *Source of Federal Funds:* Hatch, U.S. Department of Energy

d. *Scope of Impact:* United States

Key Theme: Biofuels (2)

a. *Description:* Bioprocessing of molecules derived from corn, forages, or oil seeds results in industrial products: edible and fermentable sugars, biodegradable polymers, renewable fuels, fiber, and starting feed stocks for the manufacture of industrial chemicals. Biocatalysis is the foundation of bioprocessing, and occurs as a consequence of the actions of living microorganisms, or heat-killed microorganisms, as well as through cell-free soluble or immobilized enzymes, or inorganic and organic catalysts. The fundamentals of adsorption equilibria, biospecific binding, mass transfer phenomena, and partitioning effects that apply to bioseparations development and modeling, also form the basis for fundamental research in biocatalysis. Studies of the molecular basis of transformations and microfluidic flows has led to a mechanistic explanation and mathematical model for surface directed boundary flow in microfluidic channels. This has application in capture and identification of pathogenic microorganisms, as well as design of micro-bioreactors. The other major effort in catalysis for hydrolysis of ologosaccharides has resulted in a model, validated by data from a plug flow reactor. In this case, first-order kinetics, coupled with diffusion resistance, fit data obtained for cellobiose. Runs with oligosaccharides obtained from pretreated corn fiber liquid also showed selectivity of the hydrolysis is achieved with increasing temperature resulting in a reduced formation of degradation products and aldehydes. Temperatures approaching 160 C are likely needed to maximize monosaccharide yield and minimize aldehyde and degradation product formation.

b. *Impact:* This research provides a deeper understanding of the potential role of microfluidic behavior on catalysis, and the application of fixed bed catalysis to the hydrolysis of oligosaccharides. Pretreatment of cellulose containing materials is an important component of this approach since the formation of soluble oligosaccharides is a necessary condition for achieving a liquid stream that may be passed over a fixed catalyst bed for purposes of hydrolysis. The hydrolysis of oligosaccharides in a fixed bed reactor is one approach that may be used to reduce costs and introduce continuous processing of oligosaccharides to fermentable sugars in the ethanol industry.

c. *Source of Federal Funds:* Hatch, U.S. Department of the Army, U.S. Department of Energy, National Aeronautics and Space Administration, National Defense University, National Institutes of Health

d. *Scope of Impact:* United States

Key Theme: Biofuels (3)

a. *Description:* Researchers used previous results from maleic acid kinetics studies to guide the optimization of pretreating corn stover to maximize sugar yields. At optimized reaction conditions, maleic acid hydrolysis results in minimal xylose degradation, while sulfuric acid causes 3 - 10 times more xylose degradation. At low solids loadings (40 grams per liter dry corn stover solids), both acid catalysts can achieve near-quantitative xylose yields. However, at higher solids loadings (150-200 grams dry stover per liter) which are relevant for actual ethanol production, sulfuric acid results in more than 30% degradation of the xylose, even under optimized conditions. However, due to minimized xylose degradation, optimized pretreatment of corn stover by maleic acid can reach ~ 95% xylose yields with trace amounts of furfural formed. Fermentation of the resulting unconditioned hydrolysate by recombinant S. cerevisiae produced ethanol at 87% of theoretical yield, further illustrating that maleic acid does not result in the formation of inhibitors. Enzyme digestibility experiments on the residual corn stover solids show that > 90% yields of glucose can be produced in 160 hours from the remaining cellulose with cellulases (15 FPU / g-glucan). Thus, maleic acid effectively pretreats the cellulose, while also achieving high yields of fermentable xylose without additional enzymes.

b. *Impact:* Maleic acid can be more effective than sulfuric acid in extracting xylose from corn stover with minimal degradation. The maleic acid extracted xylose can effectively be fermented to fuel ethanol by recombinant yeast. This potentially increases fuel ethanol produced per ton of corn stover.

c. *Source of Federal Funds:* Hatch, U.S. Department of the Army, U.S. Department of Energy, National Defense University

d. *Scope of Impact:* United States

Key Theme: Innovative Farming Techniques (1)

a. *Description:* Light-emitting diode arrays have been developed to compare intracanopy versus overhead lighting of cowpea crops in controlled environments. Stands under the overhead array were less productive than those with intracanopy lighting. Converting kW-h to g DW biomass was 70% more efficient for intracanopy lighting. Red/blue ratio can prevent leaf intumescence in cowpea, with blue radiation being critical. An intracanopy versus overhead fruit-yield comparison is under investigation for 'Triton' pepper. Reproduction occurs normally under both lighting conditions. Viviparous seed germination, common in greenhouses, was minimal in fruits with Light-emitting diode lighting. Although fruit production by the intracanopy crop lagged the overhead crop, less than half of the vertical intracanopy light engines are energized while all of the horizontal overhead ones are.

b. *Impact:* This is the century of the life sciences, of biotechnology, and of controlled-environment agriculture. Genetically improved pharmaceutical, food, and ornamental crops will command high monetary value in the market place. Certain transgenic traits will require containment, isolation, and

security for their production in controlled environments as well as the processing of value-added crop harvest. Year-round production of such high-value crops in any locality, regardless of climate, will eliminate the need for expensive, long-distance transportation costs and be environmentally friendly. Although contained controlled-environment agriculture is energy intensive, production costs can be reduced substantially by automation, identifying optimizing conditions for controlled-environment crop production, developing energy-saving methods for crop lighting, and leveraging locally available, cheap energy sources. Crop-lighting systems that are low-power-requiring, are relatively cool, long-lived, that emit only the most efficiently absorbed wavelengths, that target all competent leaves within a crop stand, and which automatically sense the position of those leaves throughout crop development will cut controlled-environment lighting and associated heat-rejection costs exponentially. Light-emitting diode-based intracanopy and close-canopy lighting systems under development will meet those requirements.

c. *Source of Federal Funds:* Hatch, National Aeronautics and Space Administration

d. *Scope of Impact:* United States

Goal 2: SAFE AND SECURE FOOD AND FIBER SYSTEM

Overview: The safety and protection of the U.S. food supply continues to be a very important public health and economic consideration for the food industry, regularity agencies, and consumers. The Centers for Disease Control and Prevention (CDC) estimates that 76 million cases of foodborne illnesses, 325,000 hospitalizations, 5,500 deaths, and costs of $7.7-$23 billion occur each year in the United States. Since September 11, 2001, the possibility of intentionally added hazards (bioterrorism) has also become a new and key focus. Integrated research and Extension-based programs have been developed at Purdue University, focusing on providing useful information to researchers, the food industry, regulatory agencies, and the general public. This portion of the report describes some of our efforts related specifically to food handling, food quality, food safety, food security, and food pathogen protection. Our efforts related to food handling have focused on developing effective educational programs to teach safe food handling practices for "high-risk" areas of the food flow including retail food establishments and raw produce farming operations. Food quality efforts have focused mainly on control of insects and weeds on crops using novel interventions and understanding crop genetics that can confer pest resistance. Food safety related research has been designated to more clearly understand microbial ecology in food systems and in animal intestines that may impact human food safety. Programs have also been established to study chemical contamination and risk for fishery products. A team of researchers is studying infectious agents deriving from animals and helping to minimize risks to human health leading to a more secure animal food supply. For foodborne pathogen protection, considerable resources have been dedicated to identifying effective detection (microbial and chemical) and intervention strategies that could be implemented by the food industry and regulatory officials.

Successes:

- Four successful food safety programs have been developed to teach safe food handling practices for retail food managers and workers – including the importance of time and temperature control, cleaning and sanitizing, good personal hygiene, and cross contamination control.
- A number of Purdue University field staff and on-campus faculty have delivered Good Agricultural Practices training for the fruit and vegetable industry to improve food handling practices and reduce risk of raw produce.
- Purdue Extension Educators conducted a series of venison workshops and discussed information about proper meat handling and safety, and provided an update about chronic wasting disease in Indiana.
- A demonstration trial was conducted to determine the efficacy of ozonation to control insect pests.

- Remote sensing-based site-specific weed management is being performed for spearmint and peppermint crops to offer great potential to decrease weed control costs.
- A test kit developed by Woods End Research (Mount Vernon, Maine) has been adapted for measurement of the resistance of shelled corn to invasion by storage fungi.
- An extensive testing program has been developed for identifying PCBs in fishery products.
- Researchers are identifying key factors involved in feeding and transport that impact intestinal microflora.
- A wide variety of foodborne pathogen detection platforms are being developed for more rapid and accurate detection and identification. This effort involved 5 schools on campus through a multi-disciplinary center called the Center for Food Safety Engineering.
- Novel thermal and non-thermal interventions are being developed to inactivate microorganisms or prevent their growth.

Benefits:

- Over 80% of the participants of retail food safety programs follow better food handling practices as a result of the training.
- As a result of Good Agricultural Practices training, 98% thought the program helped improve their field practices, 90% thought the program helped improve their worker sanitation and hygiene, 90% thought the program helped improve their packinghouse operation, and 83% thought they would make changes to their operation based on what was learned in the workshop. Food handling changes included were: washing hands more, manure storage, washing produce more, cleaning washers better, washing equipment, clean bathrooms, timing of manure spreading, and the use of chlorine.
- Ninety-eight percent of respondents of Purdue Extension workshops indicated they learned field-dressing tips that would help them keep a venison carcass clean and free of contamination.
- Ozonation of grains will benefit producers, handlers and processors of food grains valued at more than $1.5 billion that will be interested in utilizing this new technology throughout the north central region and other U.S. grain growing regions.
- Sensing for weed control in spearmint and peppermint will result in an improved ability for weed management in mint production by allowing targeted application of herbicides.
- The test kit for corn will be used to estimate the risk associated mold contamination of stored corn and whether corn is suitable for shipment overseas.
- Testing of PCBs will help us to better understand the risks from mercury following fish consumption.
- Prebiotics and probiotics, feed type, and transportation conditions have been found to have a strong impact on intestinal microflora. Knowledge here would help identify methods to better ensure animal health and food safety.
- Microbial detection platforms have been developed for detection of bacteria like Salmonella spp., Listeria monocytogenes, and Escherichia coli as well as for Fusarium mold. Several different technologies have been constructed included polymerase chain reaction, immuno-assays, bioluminescene, DNA technology, light scattering, and development of integrated biochips.
- Novel interventions, such as the use of chlorine dioxide gas, have been used to successfully reduce pathogen loads on fruit and vegetable products. A better understanding of thermal inactivation of Listeria monocytogenes has also been identified for high-risk ready-to-eat processed meats.

State Assessment of Accomplishments:

Integrated research and Extension activities under this goal are contributing to safer processing and handling of food. Assessment metrics suggest retail and wholesale food handlers are adapting safer food practices.

Resources:

Approximately $1.28 million of Federal formula funds and $7.1 million of state funds plus 66.6 FTEs have been invested in Goal 2. These are best estimates and are not presented as auditable numbers.

Key Theme: Food Handling (1)

a. *Description:* Foodborne illness continues to be an important concern for consumers nationwide. The Center for Disease Control (CDC) estimates that between 76 million cases of foodborne illness, 325,000 hospitalizations, 5,500 deaths, and costs of 7.7-23 billion dollars may occur each year. Many of these reported foodborne illnesses have been attributed to the end of the food production chain through retail food establishments (restaurants, institutions, supermarkets, convenience stores, etc). One of the important keys to prevent foodborne illness is through effective education and training for retail food establishment employees. Many states, including Indiana, have considered and implemented mandatory food safety training and/or certification examination programs. Indiana now requires at least one retail food manger from each retail food retail establishment be certified in retail food safety and pass a nationally recognized exam. The focus is to prepare retail food managers for this requirement and teach sound food handling procedures. Four retail food safety training programs have been developed that are used in the state. Retail food certification is offered using the ServSafe, Essentials of Food Safety and Sanitation, and SuperSafeMark program. A program called "Food Safety Day" is also available, and while it does not offer certification, it is an excellent resource to train front line foodservice workers.

b. *Impact:* For all four programs combined the demographic data collected indicate that the most likely job position for participants is chef or cook (30%), manager (24%), and server (16%). Most participants have a high school degree (48%) and an additional 32% have some college education. 73% have worked in foodservice for 3 or more years, 17% for less than 1 year, and 10% for 1-3 years. Also 93% are Caucasian, 4% Hispanic, 2% African-American, and 1% Asian. Five questions related to food safety handling practices were asked: hand washing, temperature control for cooking, temperature control for cooling, separation of raw from ready-to-eat foods, and cleaning/sanitizing practices. Over 80% of the participants followed better food handling practices as a result of the training. The Food Safety Day program, in particular, provided useful data. Before training, participants only answered 46% of safe food handling questions correctly. After training, this improved to 82% correct answers. In total, 111 retail food safety programs were offered in 20 different counties by 21 different Extension Educator teams. For the certification programs, a 96% passing rate was reported compared to the national average of 81%.

c. *Source of Federal Funding:* Hatch, USDA-Cooperative State Research, Education, and Extension Service

d. *Scope of Impact:* Indiana

Key Theme: Food Handling (2)

a. *Description:* The Ohio and Indiana Specialty Crop Food Safety Initiative is designed to assist Ohio and Indiana commercial fruit and vegetable growers to increase the safety and marketability of the food they produce. Encouraging the adoption of ‘common sense’ Good Agricultural Practices is the centerpiece of the Initiative, resulting in marketing and legal risk reduction. Good Agricultural Practices reduce the potential of microbial contamination of produce by emphasizing clean soil, clean hands, clean water and clean surfaces.

b. *Impact:* There were 74 people in attendance. About 91% felt the effectiveness of the presentation was good to excellent. Also 82% felt the effectiveness of the speaker was good to excellent, 88% felt the length of the program was good to excellent, 79% felt the choice of topics was good to excellent, 82% felt the brochures/handouts were good to excellent, 92% ranked the overall program good to excellent with

8% ranking it fair. Approximately 99% felt the program emphasized clean soil, clean water and clean surfaces, 98% had an increased awareness and understanding of the benefits of adopting Good Agricultural Practices, 90% were assisted in the adoption of Good Agricultural Practices, 80% were assisted in preparing third party audits, 98% thought the program helped improve their field practices, 90% thought the program helped improve their worker sanitation and hygiene, 90% thought the program helped improve their packinghouse operation, and 83% thought they would make changes in their operations based on what was learned in the workshop that evening. Some of the changes they would make were: wash hands more, manure storage, wash produce more, clean washers better, wash equipment, clean bathrooms, timing of manure spreading, and the use of chlorine.

c. *Source of Federal Funding:* Hatch

d. *Scope of Impact:* Multi-State

Key Theme: Food Handling (3)

a. *Description:* Purdue University partnered with Mid American Ag and Hort Services (MAAHS) to bring Good Agricultural Practices information to Indiana growers through a variety of means. MAAHS distributed copies of Cornell's Good Agricultural Practices publications to growers who requested them. The work was funded by a grant to MAAHS from USDA/RMA.

b. *Impact:* Fresh fruits and vegetables contaminated with pathogens can cause outbreaks of foodborne illness. Fruit and vegetable producers in Indiana need to know what they can do to minimize contamination during production, grading, and packing of fresh produce. By partnering with Mid American Ag and Hort Services (MAAHS), it was possible to bring Good Agricultural Practices information to Indiana growers through a variety of means. Food safety educators presented at grower meetings, wrote technical articles, and provided individual consultations. As a result of these activities, fruit and vegetable growers have become more aware of food safety issues related to fresh produce. Some have already made changes in their operations to reduce risk; others plan to. Examples of changes include training employees, improved toilet facilities for the field, and improved hygiene practices.

c. *Source of Federal Funding:* Hatch, USDA – Section 406 Grant, USDA – Food Safety Engineering Center

d. *Scope of Impact:* Indiana

Key Theme: Food Handling (4)

a. *Description:* Purdue Extension Educators conducted a series of venison workshops in three Indiana counties; Vigo, Hamilton, and Wayne. During the workshop, the educators discussed the proper techniques for field dressing and aging of deer; skinned and quartered the deer; discussed proper storage and preservation methods; cut up the meat and prepared it in a variety of ways for participants to taste. Educators also presented information about proper meat handling and safety, and provided an update about chronic wasting disease in Indiana. At the conclusion, participants had the opportunity to sample venison products donated by local deer processors.

b. *Impact:* One hundred and seventy one participants from 31 Indiana counties and Ohio and Illinois attended the programs with 128 participants returning the program evaluation. Ninety-eight percent of respondents indicated they learned field-dressing tips that would help them keep the carcass clean and free of contamination. Ninety nine percent indicated they had learned something about food safety, and

98% responded they had learned how to make better use of the meat. Also, 97% of respondents indicated they planned to change how they handle their deer meat after attending this workshop. One hundred percent of the respondents would like to see similar workshops in the future that focused on additional upland game and fish.

c. Source of Federal Funding: Hatch

d. Scope of Impact: Midwest

Key Theme: Food Quality (1)

a. Description: In collaboration with Kansas State University, a demonstration trial was conducted to determine the efficacy of ozonation to control insect pests. The basic setup for ozonation site consisted of generating ozone with a new generator, introduction in the headspace, drawdown to the plenum with a suction fan, and re-circulation of ozone back into the bin headspace. Ozonation was done to attain an ozone concentration of 50 ppm in the plenum and maintained for a period of three days to achieve mortality of insects comparable to phosphine fumigation. The trials proved the efficacy of ozonation in achieving stored product insect mortality comparable to phosphine fumigation. Samples are currently being evaluated to confirm that end-use parameters like millability and baking volume were not affected.

b. Impact: This research addresses the need to develop and apply Integrated Pest Management (IPM) management practices to prevent and control the infestation of stored grains by insects. This research focuses on evaluating the efficacy of ozone as a new tool for the management of stored food grains. Ozonation is a potential alternative to conventional pest control treatments. A number of food grain producers and handlers have expressed interest in ozonation technology and generators are becoming commercially available for use. Completion of this project will benefit producers, handlers and processors of food grains (conventional and organic wheat and barley) valued at more than $1.5 billion who will be interested in utilizing this new technology throughout the North Central and other U.S. grain growing regions (e.g., California, where rice is valued at more than $352 million).

c. Source of Federal Funding: Hatch, USDA-National Research Initiative, Midwest Advanced Food Manufacturing Alliance, North Central Region Integrated Pest Management, Small Business Initiative Research

d. Scope of Impact: United States

Key Theme: Food Quality (2)

a. Description: Insects and fungi (molds) contribute to quality deterioration of stored grains and food, and thus it is essential for the food storage and production industry to have effective pest management programs to protect against contamination by insects, molds and mycotoxins. This problem was addressed in three different ways: sanitation influences on trap catch, ozone as a grain protectant, and a comparison of two fumigants used for structural and commodity pest treatment. The first project examined the influence of sanitation on red flour beetle trap catch. The distance the insect travels to a trap decreases as the level of sanitation decreases, and within a sanitation level (high, med or low) as the distance to a trap increases, the percent capture decreases. The second approach, ozone, has been examined in the field against stored grain pests and in the lab against other urban pests. Field research indicates that ozone can

be an effective management tool for the food industry in the grain trade. It also shows great promise as a control strategy for other urban pests. Sulfuryl fluoride had 100% mortality of the pupal stage, but low initial survivorship of the egg stage. The majority (99.3%) of red flour beetle larvae from treated eggs died before the adult stage.

b. *Impact:* In the United States more than 15 billion bushels of grain are stored every year. Total annual storage losses are estimated at more than $500 million. Therefore, preventing the deterioration of quality and nutritional value during storage is critical. As a result of the Montreal Protocol, methyl bromide, a major fumigant for the food industry, is facing a mandatory 100 % production and importation phase out. Millers, food processors and fumigators are looking for replacements. Sulfuryl fluoride is one replacement strategy that was recently labeled for the food market. All life stages (eggs, larvae, pupae, and adults) of two major pest species, Indian meal moth and red flour beetle were used in bioassays exposed during fumigations. Insect monitoring was conducted before and after the fumigations to determine the existing pest population and rebound rates. Results indicate 100% mortality of larval and adult stages of both species for both fumigants. In addition, sulfuryl fluoride had 100% mortality of the pupal stage, but low initial survivorship of the egg stage. The majority (99.3%) of red flour beetle larvae from treated eggs died before the adult stage. Methyl bromide had 100% mortality of Indian meal moth pupae.

c. *Source of Federal Funding:* Hatch

d. *Scope of Impact:* United States

Key Theme: Food Quality (3)

a. *Description:* Peppermint and spearmint are grown as high value essential oil crops in the Midwestern U.S. (IN, MI, and WI) and the Pacific Northwest (OR, WA, MT, and ID). Remote sensing-based site-specific weed management offers great potential to decrease weed control costs by simplifying weed detection and producing site specific herbicide application maps. In order to automate the process of turning a remotely sensed image into an herbicide application map, some type of spectral identifier is needed that can be used to differentiate weed-free pixels from weedy pixels. This research developed spectral vegetation indices for differentiating mint and key weed species. Our objective was to apply spectral vegetation indices calculated from handheld spectroradiometer reflectance data to reflectance data calculated from airborne hyperspectral images to determine which method had the highest accuracy for differentiating between mint and weeds in the image. Spectral vegetation indices calculations were made from experimental field plots of peppermint, spearmint, giant foxtail, white cockle, tall waterhemp, Powell amaranth, common lambsquarter, and velvetleaf. Spectral vegetation indices based on simple ratios of reflectance values in the near infrared and green portions of the spectra accurately differentiated between peppermint and weed species, while simple ratios of near infrared and red reflectance values accurately differentiated between spearmint and weed species. The ratio of mint to weed spectral vegetation indices values was approximately 2 to 1 in both instances even though the absolute values of spectral vegetation indices varied between spectroradiometer and image calculations. The 2X difference in spectral vegetation indices values can be used to identify weedy areas of a mint field in a hyperspectral image and allow accurate targeting of postemergence herbicide applications which would reduce costs and increase efficiency of weed management for growers.

b. *Impact:* This research will result in an improved ability for weed management in mint production by allowing targeted application of herbicides. The long-term impact of site-specific weed management will result in reduced application of herbicides and lowered environmental load of pesticides.

c. *Source of Federal Funding:* Hatch, North Central Integrated Pest Management

d. *Scope of Impact:* United States

Key Theme: Food Quality (4)

a. *Description:* A test kit developed by Woods End Research (Mount Vernon, Maine) has been adapted for measurement of the resistance of shelled corn to invasion by storage fungi. The test can be completed in two to three days. To date, the test kit has been used to evaluate over 90 samples of shelled corn having distinct differences in quality and varying storage histories. The results demonstrate that the test kit can distinguish differences in susceptibility to fungal invasion. Additional measurements conducted on the samples included the following: difference in ppm ergosterol (a measure of fungal growth) before and after rewetting and incubation; NIR reflectance (830 to 2500 nm); percent kernel infection by plating on agar; electrolyte leakage, and kernel damage. Results continue to be analyzed for the purpose of determining how they can best be interpreted and utilized. Changes in procedures that would give even more accurate storability measurements are also being evaluated. In addition, a series of relatively rapid tests, requiring less than 15 minutes to complete, were conducted on all samples. The goal was to identify which combination of these more rapid tests could be used for storability screening of samples. Those identified as having a low storability using the screening procedure could then be evaluated more thoroughly using the test kit.

b. *Impact:* The test kit is capable of determining the susceptibility of shelled corn to fungal invasion in two to three days. In an attempt to better determine how the test kit could be utilized by the grain industry, the company is currently collaborating with a grain testing service located in West Lafayette. Once the test kit is available to the industry, the results could be used to estimate the risk associated with continuing to hold a given lot of shelled corn in storage and whether the corn is suitable for shipment overseas to tropical regions of the world.

c. *Source of Federal Funding:* Hatch

d. *Scope of Impact:* United States

Key Theme: Food Quality (5)

a. *Description:* (1) Using x-ray experiments, it was determined that the gel-forming carbohydrate called iota-carrageenan forms sturdy spiral shapes, known as double helices, in which the two chains coil around each other. The helix core is fairly rigid, but the sulfate groups on the molecular surface are relatively flexible. Nearby sodium ions and water molecules bind the sulfate groups and connect adjacent helices to varying degrees. This process promotes at least three ordered arrangements, crystalline states, which in turn control the final gelling properties. (2) Using partial alpha-amylase treatment for a series of dosage and reaction time, different digestion rates were obtained for gelatinized retrograded maize starch. X-ray diffraction analysis revealed that the crystalline structure in the treated starches survived cooking. These starches have slowly digestible and resistant character.

b. *Impact:* The molecular details of sodium ions and water surrounding iota-carrageenan helices govern the final gelling properties. Sowly digestible maize starch with resistant character can be produced by partial alpha-amylase treatment.

c. *Source of Federal Funding:* Hatch

d. *Scope of Impact:* United States

Key Theme: Food Quality (6)

a. *Description:* Efforts to understand how the cells of the insect gut (Drosophila melanogaster and Callosobruchus maculatus) attempt to cope with toxic or anti-nutritional factors ingested with the food have proceeded. Chief progress thus far has been in the area of methodology development, specifically: (i) procedures for administering specific quantitative doses of test substances (including cysteine protease inhibitors, serine protease inhibitors, lectins, and non-nutritional cellulose) have been established and; (ii) techniques for determining the number of guts necessary to obtain required amounts of protein or m-RNA for genomic and proteomic studies. These techniques are currently being applied with both species. Initial results indicate that there are dramatic changes in gene expression and protein in gut tissues following ingestion of anti-nutritional factors. Preliminary results from experiments with transgenic cowpea seeds expressing the alpha-amylase inhibitor from common bean indicate that such cowpeas exhibit resistance to cowpea weevil, Callosobruchus maculatus.

b. *Impact:* Genetic engineering of crop plants to impart resistance to insects is now a well-established and widely adopted technology for insect management. While genes from the bacterium, Bacillus thuringiensis, have been the primary genes used to confer insect resistance, additional genes and combinations of genes need to be explored for potential future applications. The current work shows that certain combinations of genes may be useful for the control of the cowpea bruchid feeding on cowpea grain. The present work also demonstrates for the first time that modern CAT-scanning technology can be used to gain new insights into insect resistance in seeds. It is anticipated that this new tool will be applied for other insects and crops in future.

c. *Source of Federal Funding:* Hatch

d. *Scope of Impact:* Global

Key Theme: Food Safety (1)

a. *Description:* Persistent pollutants, like PCBs and mercury, continue to pose a health risk to consumers of sportfish and commercial fish as demonstrated by the issuance of federal and state fish consumption advisories for sensitive populations. The effects of phytochemical-rich foods on bioaccessibility were investigated using an i*n vitro* digestion. Total mercury in the aqueous phase following a simulated digestion of fish along with food sources was used to measure bioaccessibility. Green tea (31-2000 mg), black tea (31-2000 mg), soy protein (50-100 mg), and sodium copper chlorophyllin (SCC, 0.1-25 mg) significantly reduced mercury bioaccessibility in a dose dependent manner (by 82-92%, 88-91%, 44-87%, 49-89%, respectively). Grapefruit juice (0.5-10 mL) did not provide a dose-response relationship. Wheat bran (50-1000 mg) decreased mercury bioaccessibility (84%); oat bran and psyllium only reduced bioaccessibility (by 59-75%, 15-31%, respectively) at concentrations greater than 500 mg. Mercury uptake by TC7 clone of Caco-2 cells was measured after 6 hours incubation at 37C. There was a lower cellular uptake of mercury with black tea when compared to green tea at both 31 and 62.5 mg; soy protein

decreased mercury uptake at 100 mg; SCC caused a significant reduction at 1-25 mg; and grapefruit juice (0.5-10 mL) had no effect. Wheat bran reduced cellular mercury uptake more than oat bran at 100-1000 mg; but psyllium (50-1000 mg) had no significant effect on cellular mercury uptake. This study predicts that foods can reduce methylmercury bioavailability following fish consumption.

b. *Impact:* Environmental pollutants pose a substantial risk to nursing infants. Many of these toxicants (i.e., PCBs, PBDEs, mercury) are passed from the maternal diet to the nursing infant in breast milk. Understanding the toxicokinetics will offer improved risk assessments which are necessary to protect the nursing infant from exposure to environmental pollutants. This research describes the effects of foods on mercury bioavailability. These findings may also help us to understand how dietary factors can affect mercury clearance. Also this research will help to eventually reduce exposure and risk from environmental pollutants that are found in fish.

c. *Source of Federal Funding:* Hatch, USDA - Initiative for Future Agriculture & Food Systems

d. *Scope of Impact:* United States

Key Theme: Food Safety (2)

a. *Description:* Bacterial pathogens are a significant problem in our food supply and an important food safety concern. They can potentially contaminate our food along the chain from initial production to the consumer. Understanding how these organisms colonize and survive on food and in the environment might provide information allowing alternate strategies to reduce the risk of contamination. This research has determined factors affecting the survival of pathogens in the environment. Specifically, bioluminescent organisms, which can detect the availability of carbon which can be utilized for energy and growth of the microbe, were generated. These organisms provide a rapid response and allow the assessment of the environment for sustainability of the organism. The same organisms also allow the examination of susceptibility of organisms which have colonized the food to standard intervention technologies for disinfection.

b. *Impact:* The potential impact of this research is a fundamental shift in how we determine pathogen threats in the environment from their enumeration to their potential for survival. Understanding the fundamental principles which allow their survival and resistance will provide alternate strategies for reducing their numbers.

c. *Source of Federal Funding:* Hatch, USDA – Agricultural Research Service

d. *Scope of Impact:* United States

Key Theme: Food Safety (3)

a. *Description:* The objective of this project was to characterize the prevalence of salmonella in the on-farm production environment. Facilities that housed pigs in the grower/finisher stage of production were selected for sampling because clinical disease in pigs is typically associated with older animals. A pilot project was performed where the physical environment of six grower/finisher facilities were sampled using the technique of environmental sampling. Two grower/finisher rooms were sampled on each farm at different times and four swabs were collected from each room. Samples were transported to the microbiology laboratory and plated onto selective media for growth of salmonella. Culture of the grower/finisher rooms failed to recover salmonella from the production environment of the farms

sampled. Sampling of grower/finisher facilities will be repeated with an increase in the number of swabs collected to improve the possibility of recovering salmonella.

b. *Impact:* The difficulty in recovering salmonella from the grower/finisher facilities is in agreement with reports from other investigators who have observed that isolation of the organism from the on-farm production environment is inconsistent. Whereas the process of transporting and holding pigs in slaughter facilities prior to processing induces sufficient physiological changes that promote shedding and excretion of salmonella from pigs that failed to show clinical signs of salmonella infection on the farm. It appears that a critical area of consideration with regards to minimizing the impact of salmonella on the food supply would be pre-harvest interventions that effectively reduce post-harvest shedding.

c. *Source of Federal Funding:* Hatch

d. *Scope of Impact:* United States

Key Theme: Food Security (1)

a. *Description:* Samples were collected to standardize the following immunohistochemical tests for the following infectious agents: Caprine arthritis encephalitis virus, Cryptosporidium, avian influenza, Sarcocystis neurona, and Toxoplasma. Standardization of immunohistochemical tests was performed for each antigen to determine optimal assay conditions. These conditions included antigen retrieval methods (e.g., proteinase K, steamer) and different dilutions of the primary antibody. To rule out possible cross-reactivities, tissues lacking the antigen were investigated (negative tissue controls). Results were compared based on the intensity of the reaction and the number of infected cells. Positive results were those in which the reaction was present in the expected location (intracellular, membrane or intranuclear) and absent in the negative control. Over 6,000 samples of ovine and deer tissues were tested for surveillance of transmissible spongiform encephalopathies (scrapie in sheep and chronic wasting disease in cervids).

b. *Impact:* These tests have improved the quality of service provided to livestock owners.

c. *Source of Federal Funding:* Hatch

d. *Scope of Impact:* United States

Key Theme: Food Pathogen Protection (1)

a. *Description:* Three areas were studied for the detection and control of microorganisms in foods. Objective one was to develop a method to release DNA from Fusarium conidia for use in polymerase chain reaction (PCR) for mold detection in foods. Objective two was to complete a project on the predictive model for post-process pasteurization of frankfurters that contain Listeria monocytogenes that have been grown under different conditions because L. monocytogenes continues to be a concern in processed meats and more information is needed to determine post-process lethality. Objective three was to study the growth of spoilage bacteria on ham and to determine how it then affects Listeria monocytogenes because there have been several recalls of ham due to contamination by L. monocytogenes. For objective 1, the FastPrep extraction of DNA using up to 6 treatments cycles of 40 seconds produced a 40 to 52% lysis rate for Fusarium verticillioides conidia. The use of lyticase gave a 3% lysis rate to release the DNA from 100,000 conidia of Fusarium verticillioides. Research is continuing to improve the rate of DNA lysis from the conidia by these two methods. For objective 2, L.

monocytogenes cells grown in tryptic soy broth containing 0.6% yeast extract (TSBYE) and in 8.5% fat frankfurter slurry had D-values at 60 C of 2.2 minutes and cells grown in 23% and 11% fat frankfurter slurries had D-values at 60 C of 1.7 minutes. L. monocytogenes cells grown in tryptic soy broth with 25 ppm quaternary ammonium compounds had D-values at 60 C of 1.0 minute. For objective 3, twenty-eight strains each of lactic acid bacteria and Bacillus species were screened for their ability to inhibit the growth of Listeria monocytogenes on agar spot assays. Those that showed the greater inhibition were further screened against six Listeria monocytogenes strains at various concentrations and for sensitivity to proteinase K. Bacillus species were not as effective as lactic acid bacteria at low levels and only one species inhibited all six strains of L. monocytogenes.

b. *Impact:* The research on the development of a protocol to release DNA from mold spores suggests that if this method can be further optimized, then a rapid method for mold detect can be developed. The predictive model for post-process killing of Listeria monocytogenes in hot dogs was submitted to the USDA to add to the Pathogen Modeling Program and to ComBase, which are computer programs maintained at the USDA website that can be used by the meat industry to develop thermal processes for their products. The research on the growth of spoilage bacteria in the presence of L. monocytogenes may result in the discovery of a natural antimicrobial agent that may be effective in preventing L. monocytogenes from growing in ham and other processed meats.

c. *Source of Federal Funding:* Hatch, USDA-Agricultural Research Service

d. *Scope of Impact:* United States

Key Theme: Food Pathogen Protection (2)

a. *Description:* Consumers and restaurateurs are increasingly purchasing raw fruit and vegetable products. Recent foodborne outbreaks associated with these products have promoted the industry and regulatory agencies to seek alternative intervention treatments. The purpose of this study was to evaluate the inactivation of common foodborne pathogens exposed to chlorine dioxide gas treatments on selected fruit and vegetable surfaces (tomatoes and strawberries). Inactivation of Escherichia coli O157:H7, Listeria monocytogenes and Salmonella spp. on strawberries by chlorine dioxide gas at different concentrations (0.5, 1.0, 1.5, 3.0 and 5 mg per liter) for 10 minutes were studied. Approximately a 4.3-4.7 log CFU reduction per strawberry of all examined bacteria was achieved by treatment with 5 mg per liter chlorine dioxide for 10 minutes. More than a 3 log CFU reduction per strawberry was achieved by treatment with 1.5 and 3 mg per liter chlorine dioxide for 10 minutes. The bactericidal effect of ClO2 against these bacteria was increased by increasing chlorine dioxide concentration and/or treatment time. The inactivation kinetics of Escherichia coli O157:H7, Listeria monocytogenes and Salmonella spp. were also determined. The D-values of E. coli, L. monocytogenes and Salmonella were 4.7, 4.6 and 4.2 minutes, respectively at 0.5 mg per liter chlorine dioxide after 10 minutes. While, the D-values of E. coli, L. monocytogenes and Salmonella spp. were 2.6, 2.3 and 2.7 minutes, respectively at 5 mg per liter chlorine dioxide after 10 minutes. The next objective was to determine survivability of Salmonella spp. and Listeria spp. on hydroponic tomatoes after treatment with chlorine dioxide gas. The goal was to achieve a 5 log reduction consistent with the recommendations of the National Advisory Committee on Microbiological Criteria for Foods (NACMCF). The mixed culture of Salmonella was inoculated onto tomato skin, stem, and stem scar areas. The tomatoes were then treated with 0.0, 0.3, 0.5, 0.7, 0.9 and 2.0 mg per liter chlorine dioxide gas for 10 minutes at 22 C and 85% relative humidity. Stem and stem scar areas were also treated with higher concentrations (5 and 8 mg/l chlorine dioxide gas). A greater than 8 log reduction in Salmonella spp. ($p < 0.05$) was observed on the tomato skin surface after treatment with 0.3mg/l chlorine dioxide gas for 10 minutes.

b. *Impact:* These results imply that the treatment with chlorine dioxide gas has a very powerful antimicrobial effect against tested pathogenic bacteria on produce. This relatively new technology could be a viable alternative for pathogen reduction methods used to make produce safer.

c. *Source of Federal Funding:* Hatch, USDA-Cooperative State Research, Education, and Extension Service, USDA – Section 406 Grant, USDA – Food Safety Engineering Center

d. *Scope of Impact:* United States

Key Theme: Food Pathogen Protection (3)

a. *Description:* A bioluminescent derivative of E. coli O157:H7 C7297, designated E. coli O157:H7-lux, was constructed and is highly bioluminescent when grown in rich media. The level of bioluminescence is dependent on several factors, including oxygen, high energy compounds, and a fatty acid substrate. The resultant bioluminescence E. coli O157:H7 cells can be conditioned in minimal salt media to minimize bioluminescence, followed by the addition of test carbon sources, which increase bioluminescence if they can be utilized. To determine the usefulness of bioluminescence in the detection of metabolic available carbon from produce assays were conducted with extracts of fresh lettuce, chosen due to its relevance to food safety as a vehicle for E. coli O157:H7 infections. When carbon deprived cultures were incubated with lettuce extracts, a strong bioluminescent response was observed and was approximately 7 times the luminescence generated by a glucose control and was achieved in half the time. This result is probably due to the presence of preformed biosynthetic precursors in the whole lettuce extract alleviating the biosynthetic burden on the carbon-deprived cells and less energy is required for the synthesis of necessary compounds.

b. *Impact:* The developed assay utilizing bioluminescence and carbon deprivation showed its applicability to detect the presence of metabolically available carbon in both simple and complex carbon sources using increases in bioluminescence. Previous applications of luminescence for the detection of available carbon simply used bioluminescence as an indicator of cell number (i.e., a more rapid analysis of growth). The assay developed in this study is focused on increased metabolic activity, as measured by luminescence, not an increase in cell numbers, although that may occur. The kinetics of luminescence also provides insight into the one of the key issues in the contamination of lettuce. This bioluminescence assay will allow investigation of produce that pose food safety risks, due to high levels of metabolically available complex carbon.

c. *Source of Federal Funding:* Hatch, USDA-Agricultural Research Service, USDA – National Research Initiative

d. *Scope of Impact:* United States

Key Theme: Food Pathogen Protection (4)

a. *Description:* A portable and automated fiber-optic biosensor, RAPTOR (Research International, Monroe, WA), was used to detect Salmonella enteritidis food samples. A binding inhibition assay based on the biosensor was developed to detect the bacteria in hotdog samples. The biosensor and the binding inhibition assay could detect one million cfu/ml of bacteria in less than 10 minutes of assay time. A method for detecting Listeria monocytogenes in food samples was also developed using the RAPTOR, automated biosensor. Again, detection of Listeria monocytogenes in hotdog samples was evaluated. A

sandwich assay method could detect 1000 cfu/ml of Listeria monocytogenes in PBS. The benefits of such a sensor platform include its ease of use and rapid response to a sample containing bacteria. A second project included the development of a novel method to activate the surface of food contact packaging material. Research that has been performed so far includes the optimization of the conditions involved for the polymerization including the selection of monomer and an enzyme substrate model.

b. Impact: The improved understanding of antibody-antigen interaction and the effects of environmental parameters can ultimately be used to design more sensitive and rapid biosensors for detection of low levels of contaminants in food products. Since current antibody-based, fiber-optic, biosensor methods cannot detect low levels of bacteria in food samples, enrichment steps to grow the cell numbers will continue to be necessary. If improved antibodies or bacteria capture proteins for the food-borne pathogen Listeria can be developed, detection limits may be improved and the entire time required for testing may be shortened. Ultimately, an improved sensor which can be used in a processing facility to monitor levels of Listeria in the plant may be possible. Early monitoring and detection of environmental pathogen presence can give a warning sign prior to the contamination of actual product. Development of an active package with immobilized enzymes or antibacterial compounds can ultimately be used to process foods in the package or improve shelf-life of processed products, respectively. Longer shelf-life products can have a significant economic gain for the industry. Novel, in-package-processed products can improve manufacturing efficiency and potentially bring new products to the market.

c. Source of Federal Funding: Hatch, USDA-Agricultural Research Service

d. Scope of Impact: United States

GOAL 3. A HEALTHY, WELL-NOURISHED POPULATION

Overview: Diet and nutritional concerns are a high priority in the United States, especially obesity. The health of the nation is dependent on the availability of high-quality, nutritious foods and the ability of the public to make good dietary choices. Diet is one of the most significant factors influencing the health of individuals. To ensure continued improvements in the well-being of the public, a deeper understanding of nutritionally affected metabolic pathways and a better understanding of dietary intake controls are essential. With this knowledge, better nutritional and dietary guidelines can be designed and new foods with improved or added benefits can be developed. Purdue University researchers have conducted basic nutritional biochemistry research, identified and quantified constituents of a healthy diet, identified foods or dietary components that will improve deficiencies or prevent future health problems, and developed raw or processed foods with traits that add both nutrition and value to current diets. This work will lead to a healthier, better-informed public capable of making choices among a wide variety of nutritious and functional foods and dietary supplements.

Purdue University researchers have made great strides in identifying natural food components that have nutritional benefits, and to providing dietary guidance to lower the risks of developing certain health problems in humans. Nutrition scientists, food scientists and plant biologists are working to develop better ways to manage a variety of factors that affect health. Purdue researchers work to deliver dietary guidance in partnership with Purdue Extension and various state and national health organizations. This cooperation provides both a means of delivery to the public and a pathway for identification of future research needs.

Successes:

- Bioinformatic and expression analysis of malaria and dengue/yellow fever mosquitoes will facilitate the development of novel insecticides.
- Understanding of how long-chain omega-3 fatty acids accumulate in bone will help control inflammatory reactions and reduce musculoskeletal atrophy during aging, spaceflight, casting, and inactivity.

- Research on rats fed diets high in fat and carbohydrates is providing insights into causes of obesity, insulin resistance/diabetes, and breast cancer.
- Dietary calcium and vitamin D prevent fat mass gain and enhance muscle mass gain in a rodent model.

Benefits:

- Understanding of the role of omega-3 fatty acids and vitamin E on behavior may help clinicians treat attention-deficit/hyperactivity disorder (ADHD) children.
- African-American girls retain calcium in bones more efficiently than Caucasians.
- While peanut oil is a heart-healthy oil, excessive consumption may contribute to weight gain.
- A web-based, interactive software helped students eat a healthier diet and increase physical activity.
- With careful planning, athletes can meet their nutritional needs on a vegetarian diet.

State Assessment of Accomplishments:

Research under this goal is addressing public needs in terms of improving the health and well-being of the citizens in Indiana and beyond. Research has clearly demonstrated ways to reduce the risk of cancer, lower the incidence of osteoporosis, and address obesity issues. Citizens are provided information regarding potential health impacts of their food choices through Extension education programs and websites.

Resources:

Approximately $ 197,257 of Federal formula funds and $ 1.733 million of state funds plus 20.78 FTEs have been invested in Goal 3. These are best estimates and are not presented as auditable numbers.

Key Theme: Human Health (1)

a. *Description:* Bioinformatic and expression analyses was undertaken to identify and characterize the repetoire of G protein-coupled receptor (GPCR) insecticidal targets in Anopheles gambiae (malaria mosquito) and Aedes aegypti (dengue/yellow fever mosquito). These mosquitoes are two of the most important insect vectors affecting human health in the world today. An. gambiae GPCRs, the conceptual amino acid and nucleotide sequences of 135 GPCRs in the genome of Ae. Aegypti, were identified using sequence similarity searches. These GPCRs are thought to function in a range of sensory and neurophysiological processes in Aedes. A comparative genomic and phylogenetic analyses was undertaken between An. gambiae, Ae. aegypti and the fruitfly, D. melanogaster to assign the Ae. aegypti GPCRs to predicted functional class and family and to identify those receptors that are species specific or common to either the mosquito or these three dipteran lineages in general. This approach was also used to identify a number of receptors that have apparently undergone rapid expansion and divergence in one or the other mosquitoes, that may be associated with a higher degree of evolutionary activity. These receptors may function in biological processes that are either highly conserved or species-specific and as such, may be candidates for strategies to disrupt mosquito life-cycle processes.

b. *Impact:* Bioinformatic and expression analyses of the repetoire of G protein-coupled receptor (GPCR) insecticidal targets in Anopheles gambiae (malaria mosquito) and Aedes aegypti (dengue/yellow fever mosquito) will facilitate the development of novel insecticides for mosquito control and reduce the transmission of insect vectored diseases.

c. *Source of Federal Funds:* Hatch

d. Scope of Impact: Global

Key Theme: Human Health (2)

a. Description: A lack of weight bearing load initiates musculoskeletal atrophy and subsequent losses in bone mineral and muscle mass and strength. Currently, the only approach for inhibiting muscle and bone atrophy associated with unloading is exercise. Dietary supplementation with mixtures of n-3 PUFA inhibits muscle and bone atrophy was combined with hindlimb suspension. Fifteen-week-old male NIH Swiss mice were fed diets (based on AIN-93G and varied only in the fat source) supplemented with n-6 (safflower oil) or three n-3 PUFA formulations (all had a ratio of n-6/n-3 = 5 using different n-3 PUFA) for 7 days, followed by 9 days of hindlimb suspension on half of the animals in each treatment group. Dual-energy X-ray absorptiometry was used to measure bone mineral density, bone mineral content, and lean and fat body mass.

b. Impact: Two important dietary sources of long-chain omega-3 fatty acids accumulate in bone at different efficiencies is relevant to controlling inflammatory reactions in the bone and joint. This research offers significant promise for reducing musculoskeletal atrophy during aging, spaceflight, casting, and inactivity.

c. Source of Federal Funds: Hatch

d. Scope of Impact: Global

Key Theme: Human Health (3)

a. Description: Studies investigating the role of photochemical antioxidants in disease prevention were completed. One study investigated the role of naringenin consumption in preventing adipose accumulation and hepatic fat oxidation in a diet-induced rat model of obesity. A second study investigated the mechanisms by which isoflavones improve insulin sensitivity in 3T3-L1 cells. The role of oxidative stress-driven fatty acid metabolism in the development of abnormal behaviors characteristic of attention-deficit/hyperactivity disorder (ADHD) was investigated. The hypothesis was tested that oxidative stress was responsible for a depletion of essential fatty acid status in an animal model of ADHD, the juvenile spontaneously hypertensive rat, the most widely accepted and utilized animal model for ADHD. The juvenile spontaneously hypertensive rat had much lower vitamin E concentrations in plasma and brain compared to the aged-matched Sprague-Dawley rats on the same diet, which was accompanied by lower levels of EFA in plasma and brain. The spontaneously hypertensive rat also had impaired learning, impaired extinction and increased impulsivity compared to the Sprague-Dawley rats.

b. Impact: This work on phytochemicals suggests that the non-nutrient flavonoids, rich in fruits and vegetables, may exert their protective antioxidant action through interaction with nutrient antioxidants and by exerting anti-inflammatory effects. Refinement of this information could lead to specific recommendations for fruit and vegetable intake to help prevent chronic diseases. Work on omega-3 fatty acids, vitamin E and behavior should eventually help clinicians provide more specific and helpful dietary recommendations for the effective treatment of children with attention-deficit/hyperactivity disorder (ADHD) and other disruptive behaviors.

c. Source of Funds: Hatch

d. Scope of Impact: United States

Key Theme: Human Nutrition (1)

a. Description: A new rat Diet-Induced Obeseity model has been established and characterized. In this model rats are fed a Western Diet that is high in fat and higher in simple carbohydrate compared to diets of traditional Diet-Induced Obeseity studies. This more closely represents the typical human diet of North America. Young female rats fed a Western diet have a higher body fat mass and elevated serum comorbidity factors as compared to Chow fed Lean rats. Furthermore, carcinogen MNU-induced mammary tumors appear sooner, in greater numbers and are more invasive in obese rats as compared to tumors from lean rats. This is in accord with the association between human obesity and breast cancer mortality. This new model provides an excellent system to identify the mechanisms of obesity towards mammary tumorigenesis.

b. Impact: The National Health and Nutrition Examination Survey estimated in 1999-2000 that nearly two-thirds of U.S. adults are either overweight or obese and nearly one-third of all adults - ~ 59 million people- are now classified as obese. In addition, 15 percent (almost 9 million) of children are overweight. In 2002, about 41,000 new cases of cancer - ~ 3.2 percent of all new cancers - in the United States were estimated to be due to obesity. In 2003, one estimation concluded that 14% of deaths from cancer in men and 20% of cancer deaths in women in the United States were due to being overweight and obese. Considering such an enormous medical problem, this study is an important attempt that tests a novel idea that SHIP2 acts as a link in obesity-insulin resistance-cancer axis. The study is in early stages and the results, although encouraging, at this stage are very preliminary. These studies, when completed, are expected to generate new insights into the molecular interplay between cancer and predisposing conditions such as obesity and diabetes. Better understanding SHIP2 function will be valuable in developing new drugs as well as cancer prevention strategies beneficial to patients of obesity, insulin resistance/diabetes and cancer.

c. Source of Federal Funds: Hatch, U.S. Department of Defense

d. Scope of Impact: Global

Key Theme: Human Nutrition (2)

a. Description: Data from previous 182 metabolic balance studies in adolescent girls were pooled to determine differences between black and white girls in calcium absorption and retention over a range of controlled intakes. This helps determine racial differences in calcium requirements.

b. Impact: Previously, it was determined that black girls utilized calcium more efficiently on bone calcium intake. This difference could explain adult racial differences in bone mass. This did not allow for determination of racial differences in calcium requirements. Blacks had consistently higher mean calcium retention than whites at all calcium intakes by 185+32 mg/d due to higher net calcium absorption and lower calcium excretion at all calcium intakes, but the slopes of the relationships were not different. Dietary calcium requirements were not different between black and white girls.

c. Source of Federal Funds: Hatch, National Institutes of Health

d. Scope of Impact: United States

Key Theme: Human Nutrition (3)

a. *Description:* The Internet-based program to help college students assess their food and physical activity choices was introduced as an extra-credit assignment in a fall 2005 and spring 2006 introductory nutrition course offered to non-nutrition majors. A total of 122 students (92 in fall 2005 and 30 in spring 2006) completed one cycle of the program. Additionally, 17 students in the spring 2006 class completed a second cycle. A second cycle was not offered in fall 2005. Students were only assessed on completing the assignment and turning in a copy of the goals they chose. From a technical standpoint the program operated quite successfully. Student progress through the program could be tracked by the instructor and most students were able to complete the whole assignment and print out their goals. Student response to the program was quite favorable. Most felt that it really helped them better understand the food and physical activity choices they were making. They felt that the goals offered were simple enough that they could actually make the changes suggested. Less positive comments focused on the length of time needed to put in the foods and activities into the database. The issue of amount of time needed was less apparent in comments from students who did the program a second cycle, indicating that familiarity with the system helped decrease the time involved. Other comments given were related to finding specific food items in the USDA database or relating a particular physical activity to one in the list of activities provided. Updates in the program and activities database were made based on the comments from the students. The program was incorporated as a regular assignment in the fall 2006 semester.

b. *Impact:* Students who participated gradually changed their eating and activity behaviors toward choices that put them in line with the Dietary Guidelines for Americans and the MyPyramid food choice system. Changes in food and activity habits made during the teenage years have a greater impact on lifelong health and wellness then changes that are made later, often after a person has already developed a chronic disease.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

Key Theme: Human Nutrition (4)

a. *Description:* An animal study investigated the influence of dietary macronutrient backgrounds (high fat or high sucrose) in the role of calcium and vitamin D on fat mass. The results demonstrated that high calcium and vitamin D diets significantly prevented fat mass gain and enhanced muscle mass gain in a rodent model. Together, dietary calcium and vitamin D prevented the development of insulin resistance, but not the reversal. A hormone regulated by dietary calcium and vitamin D, parathyroid hormone, suppresses insulin stimulated glucose uptake in both fat and muscle tissue, both critical target tissues of insulin action. The results of these studies will contribute to our understanding if dietary vitamin D or calcium may be used to stem the development of diabetes.

b. *Impact:* It is estimated that obesity costs the United States an annual $100 billion. Obesity is also a risk factor for serious chronic diseases. Diet plays a major role in the development of obesity and diabetes, and while much effort has been devoted to studying the effects of macronutrients on weight control, the role of micronutrients has not been studied as well. This study which investigated the impact and the underlying mechanism of dietary calcium and vitamin D on body fat mass and insulin

resistance will contribute to knowledge for designing public health recommendations to prevent and treat obesity as well as strategies for cancer prevention.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Global

Key Theme: Human Nutrition (5)

a. *Description:* Two studies were completed. One explored the effects of inclusion of peanut oil in daily milkshakes for eight weeks in healthy adults and the second contrasted responses from lean and obese individuals. An almond study quantified how the energy from almonds is used and lost from the body.

b. *Impact:* Studies conducted over the past year revealed that peanut oil has weaker satiety value than whole peanuts. Peanut oil inclusion in the diet led to increased energy intake and weight gain. Thus, while peanut oil is a heart-healthy oil, recommendations to include it in the diet must be tempered by consideration of its effects on energy intake. This is especially true in the obese. Work with whole almonds revealed that including 300 kcal of almonds in the daily diet for 10 weeks did not promote weight gain. This was due, primarily to their high satiety value, but limited absorption is also a likely factor. Thus, recommendations to include almonds in the diet for their beneficial effects on cardiovascular disease risk may be made with limited concern about their contribution to weight gain.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

Key Theme: Human Nutrition (6)

a. *Description:* Students in the intervention schools have completed the first evaluation of the web-based program, EAT MOVE LEARN. Students were capable of completing most of the activities and assignments. The final assignment in the RENOVATION FOR THE NATION module culminated in the students designing and testing their own intervention programs. Most of the students focused their interventions on physical activity despite the instructions to focus on both diet and physical activity. Feedback from the teachers and students has allowed the researchers to enhance the EAT MOVE LEARN modules. Examples of quotes from the teachers that worked with EAT MOVE LEARN are included here. From a sixth grade teacher in Indiana, [I've been amazed how astute the children have been regarding all the information they've learned and are able to discuss intelligently]. and [Eat, move, and learn is incredibly dynamic, kid friendly, colorful, and so much fun to just sit and watch]. From a sixth grade teacher in another school in Indiana, [The video themselves were good and kept the children engaged. I think that they were very informative, yet had a funny side to them that kept the kids engaged]. A teacher from Arizona wrote, [The students understood most of the concepts, and they understood the correlation between measuring pedometer steps and keeping track of food intake]. In a description of RENOVATION FOR THE NATION, a teacher posted, [The groups enjoyed writing the Letter to the Principal. Having the students report their findings to the Principal was extremely rewarding to them and to me]. The evaluation measures of collecting weight, height, bioelectrical impedance analysis, food intake, sedentary behaviors, and other diet behaviors in the schools were collected for 642 students (306 from Arizona and 336 from

Indiana) at baseline. The second level of evaluation that included dual energy x-ray absorptiometry (DXA) measurements for estimating percent body fat, gynoid fat, and android fat was completed on 208 students (90 from Arizona and 118 from Indiana).

b. *Impact:* The reduction and prevention of obesity among adolescents and young adults may decrease the occurrence of diabetes and cardiovascular risk factors.

c. *Source of Federal Funds:* Hatch, USDA – National Research Initiative

d. *Scope of Impact*: United States

Key Theme: Human Nutrition (7)

a. *Description:* The use of vegetarian diets by athletes was studied. Special dietary considerations to meet the nutritional needs and support peak performance among athletes includes consuming adequate energy and macronutrients within the acceptable distribution range and consuming adequate total dietary iron to offset the reduced bioavailability of iron from plant foods. The overall assessment is that all athletes should carefully plan their diet to contain sufficient energy and nutrients to fully support their training and competition. Available evidence suggests that well planned vegetarian diets can meet the energy and macro- and micronutrient needs of athletes and may reduce the risk for certain chronic diseases.

b. *Impact:* The findings from these studies collectively continue to strongly support the benefits of diet and exercise to help people maintain a healthy body weight, maintain nutritional status, and promote a healthy, anti-inflammation and immunity systems in their bodies.

c. *Source of Federal Funds:* Hatch, USDA – National Research Initiave

d. *Scope of Impact*: United States

GOAL 4: GREATER HARMONY BETWEEN AGRICULTURE AND THE ENVIRONMENT

Overview: The impact of work conducted under Goal 4, is found in our continuing support of Indiana's citizens as they work towards achieving improved environmental quality in the state. Purdue University researchers continue to develop and implement technological solutions for the conservation and management of key environmental resources, especially in agricultural and rural landscapes. Combined with Extension programs, these projects foster better stewardship of soil, water, and air among agricultural producers, land use planners, and regulators.

Under Goal 4, Purdue is providing the practices and approaches needed to sustain and enhance our natural resources, while maintaining the productivity of agricultural operations and the development of stronger rural economies.

Successes:

- Tools to reduce the transport of particulate matter, including PM10 (particulate matter of 10um and smaller) and total suspended particulate matter from animal operations have been developed and are being implemented.

- A clear definition for rates of sorption and degradation of veterinary pharmaceuticals is emerging. In particular, (trenbolone isomers) and its primary metabolite (trendione); and two ionophore antibiotics monensin and lasalocid is now available.

- The effects of crop rotation, nitrogen (N) source, rate and timing of application on crop N use efficiency, N balance in the soil, carbon (C) sequestration and N and C loss to surface water has been characterized.

- A model septic system database adaptable to every county in the country is being constructed. A county can amend the database system to fit their expertise level; a minimum dataset can be submitted to the State's Department of Health.

- Demonstrated that many native animal species can find their way to small, relatively isolated patches of habitat, and their continued presence in our region is dependent on how well these patches are interconnected. Land management to allow this interconnection is currently being developed.

- A better understanding of the influence of environmental conditions on the population biology of Great Lakes fishes, as related to development of management and rehabilitation strategies has been developed.

Benefits:

- Results of a long-term nitrogen and carbon study suggest that a 10% reduction in application rates will not adversely affect yields, but will increase economic return.

- Research is providing a number of management approaches to the reduction of nutrient loss from animal wastes. By providing a suite of approaches many different production situations can be improved.

- Land and animal ecologists are provided the tools that are needed to make better decisions about land and wildlife management. This is especially critical in the changing landscape of the Midwest.

State Assessment of Accomplishments:

Research initiatives that fall under this goal are addressing Indiana's priorities for reducing the impact of agriculture on the environment and improving quality of life, while maintaining productivity and promoting economic development. Purdue University faculty are delivering the technologies, tools, and knowledge needed to meet these challenges.

Resources:

Approximately $ 872,356 of Federal formula funds and $5.41 million of state funds plus 55.29 FTEs have been invested in Goal 4. These are best estimates and are not presented as auditable numbers.

Key Theme: Agricultural Waste Management (1)

a. *Description*: The objective of this multi-state project is to test, demonstrate, and encourage the adoption of standards and practices related to lowering the emissions rates of odor, hydrogen sulfide, ammonia, and methane from swine and poultry production facilities. In addition, emission rates of particulate matter, including PM10 (particulate matter of 10um and smaller) and total suspended particulate matter, were also measured at two 169,000-hen capacity high-rise layer barns for six months. Electrostatic Space Charge System (ESCS) was evaluated for abating PM 10 and total suspended particulate matter and a manure amendment (Aluminum sulfate and aluminum chloride) to reduce NH_3. The ESCS reduced PM10 by up to 48% and total suspended particulate matter by up to 19% and the aluminum amendment reduced NH_3 emissions by 23 to 27%. Ten lab-scale biofilters and biotrickling filters were operated to test the removal efficiencies for mixtures of acetone, n-butanol, methane, ethylene, and ammonia at concentrations from 7 to 50 ppm. Concentration of the componets in the gas phase were measured with an FTIR spectrometer and showed nearly 100% reductions of n-butanol, acetone, and ammonia, 10 to 90% reductions in ethylene, and less than 5% reduction in methane using foam, perlite and compost biofilters.

b. *Impact:* This project has provided needed information about air pollution source strength and the effectiveness of abatement technologies for animal housing systems. As a result of this work, an additional cross section of farms (a total of 19) were selected and are being used to develop a detailed research study that has become the national air emissions monitoring study. Long-term measurements of NH_3, H_2S, PM 2.5, and PM 10, and total suspended particulate matter emissions from these livestock facilities are being conducted. Measurements are scheduled to begin in summer 2007 and continue for several years. These data and findings will be utilized by stakeholders throughout the United States and represents the first major comprehensive evaluation of gas contributions from animal production facilities.

c. *Source of Federal Funds*: Hatch, USDA-National Research Initiative, and U.S. Environmental Protection Agency

d. *Scope of Impact:* Multi-state

Key Theme: Agricultural Waste Management (2)

a. *Description:* Antibiotics and synthetic hormones used to improve animal production are excreted in the animal's urine and feces. These materials are collected and stored in a lagoon or other waste management structures for an extended period of time and then applied to agricultural fields as part of nutrient management plans. The fate of the pharmaceuticals in the environment remains a concern of both the agricultural community and the public. This study is investigating the sorption and degradation of these veterinary pharmaceuticals following their storage under typical lagoon conditions. Sorption and aerobic degradation studies in soil and cobalt-radiated soil (sterile) were conducted for synthetic androgen used in the beef industry (trenbolone isomers) and its primary metabolite (trendione); and two ionophore antibiotics monensin and lasalocid their primary metabolites. Evaluations of concentrations of the chemicals monensin in manure and in surface water near an operating feedlot were conducted. In the aerobic soil degradation studies, the two alpha and beta isomers of trenbolone appear to follow similar pathways. Degradation is concentration dependent and primarily, but not completely, microbial. Preliminary testing of surface water and beef lagoon effluents showed monensin in the aqueous portion of the beef lagoon sample to be ~40 ug/L while the suspended solids fraction contained 2000 ug/kg. The monensin concentration in a drainage ditch was found to be 0.1 ug/L in the aqueous fraction and less than the method detection limit of 0.5 ug/kg in the sediment.

b. *Impact:* Although trenbolone has been reported with a half-life of nearly one year in anaerobic manure pits, once applied to an aerobic soil the chemical appears to degrade rapidly. Likewise, several antibiotics known to persist in an anaerobic environment (manure pits or lagoons) appear to degrade rapidly once applied to soils. This suggests that these animal pharmaceutical materials will have little longevity in the environment. Tetracylcines, tylosin, carbadox, monensin, and lasalocid compounds, when soil applied in manure or lagoon effluents, will degrade rapidly. Moreover, they demonstrate a short half-life in nearby water bodies, suggesting little offsite movement.

c. *Source of Federal Funds:* Hatch and U.S. Environmental Protection Agency

d. *Scope of Impact:* National

Key Theme: Agricultural Waste Management (3)

a. *Description:* This project evaluated the effectiveness of new feeding ration constructed to reduce emissions of NH3, H2S, NO, NO2, SO2, CO2, CH4 and non-methane total hydrocarbon from waste materials compared to feeding a commercial diet. The diet contained 6.9% of a gypsum-zeolite mixture and slightly reduced crude protein. There were diet and age effects on NH3 emissions. In trials 1, 2, and 3, daily NH3 emissions from hens fed the special diets were less than those of hens fed the conventional diet. Daily emissions of H2S across trials from hens fed the special diet were 4.08 mg bird-1 compared to 1.320 mg bird-1 from hens fed the conventional diet. Diet and age affected emissions of CO2 and CH4. There was an effect of diet on NO emissions and of age on SO2 emissions. No diet or age effects were observed for NO2 and non-methane total hydrocarbons.

b. *Impact:* Emergency Planning and Community Right-to-Know Act (EPCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) reporting requirement allow daily emissions of 100 pounds per day of both NH3 and H2S from poultry farms. The current study illustrated that feeding a reduced emission diet could reduce NH3 emissions by 40%. Even though gypsum addition increases H2S emissions considerably, these concentrations did not surpass reporting limits even for larger laying hen complexes. Reporting requirements for laying hens operations for CERCLA/EPCRA, therefore, will be driven by NH3.

c. *Source of Federal Funds:* Hatch, USDA – National Research Initiative

d. *Scope of Impact:* United States

Key Theme: Water Quality, Water Protection (1)

a. *Description:* The pending enforcement of regulations related to nutrient management and water quality requires that any implementation of a specific management strategy will produce a predictable effect on nutrient loading to surface water. To help achieve a balance between crop production and water quality, the goals of this project were to enhance our understanding of relationships between resource management strategies, crop productivity, and surface water quality. Specific project objectives included characterizing the effect of rotation, nitrogen (N) source, rate and timing of application on crop N use efficiency, N balance in the soil, carbon sequestration and N and carbon loss to surface water. This research is on-going at Purdue University's Water Quality Field Station where the soil is a Mollisol, typical of depressional, poorly drained soils of the eastern Corn Belt. The N and dissolved organic carbon

load to surface water introduced by subsurface tile drains is a function of soluble N and carbon concentration and drainflow volume. The impact of agricultural management systems on crop productivity and the mass N and dissolved organic carbon losses in tile drainage water is being characterized. There was no significant effect of agricultural management on mass dissolved organic carbon loss; drainflow volume governed individual treatment plot mass dissolved organic carbon loss and was the single most important determinant of within-treatment and year-to-year variation in dissolved organic carbon mass loss. Six-year flow-weighted dissolved organic carbon concentrations in spring manure treatments averaged 2.49 PPM; planned contrasts revealed that this value was significantly greater that flow-weighted- dissolved organic carbon values observed in all non-manured agronomic treatments and the restored prairie treatment. There was no significant difference in mean dissolved organic carbon concentration in drainflow from the prairie control when compared to non-manured agriculture. Both nitrate and dissolved organic carbon tended to exhibit event-driven behavior within rainfall events. Peak concentrations of these solutes occurred early in drainage events and corresponded to hydrograph peaks.

b. *Impact:* These results show that producers can reduce N rates by at least 10% and achieve the same yields if they shift the timing of application from before planting to the early vegetative stage. The work is providing detailed guidance for the development of environmentally benign, but crop intensive production agriculture. This research is improving our understanding of fertilizer use efficiency and of the active soil carbon and nitrogen (N) pools as influenced by agricultural management. As designed, this is a multiyear evaluation of effect of current N recommendation rates and lower, more agronomically efficient rates on water quality. These results are being used to guide farmers on optimizing management. This research also characterizes a previously unknown portion of the global carbon cycle and reveals that mid-western agriculture may not be contributing a disproportionate load of carbon to surface waterways. This is important because dissolved carbon in surface waters is a nutrient source, and therefore an important co-contaminant for bacterial pathogens as they are transported to new hosts via water. Also, the results show the extreme spatio-temporal variability of quantities of solutes in agricultural drainage water, information essential to the successful implementation of water quality monitoring programs aimed at improving and protecting U.S. water quality under the Clean Water Act.

c. *Source of Federal Funds:* Hatch, USDA- National Research Initiative

d. *Scope of Impact:* United States

Key Theme: Water Quality, Water Protection (2)

a. *Description:* Drainage water management is a practice for addressing nitrogen loading that is of interest to many stakeholders in the Midwest. Research and demonstration sites for drainage water management have been developed on four Indiana farms. At each site, the effectiveness of drainage water management is characterized for reducing edge-of-field nitrate loss in subsurface tile drains, and determining co-benefits and costs of the practice with respect to soil quality attributes, crop growth, yield and fertilizer N use efficiency, and profitability. DRAINMOD, a computer simulation hydrologic model, was used to study the performance of a tile drainage system at the Purdue University Water Quality Field Station and simulate the hypothetical effects of drainage water management. The historic observations from a subset of the treatment plots with continuous corn were used to calibrate the model. The model was used to simulate the potential effects of drainage water management on hydrologic parameters and corn yield over a period of 7 years from 1997 to 2003.

b. *Impact:* The first multi-state extension publication on drainage water management has been written and widely distributed. Preliminary results have been presented at three conferences, and hundreds of farmers and contractors have been informed about drainage water management through presentations and workshops around the state. Based on these efforts, related efforts in neighboring states, and a new multi-state project, dozens of farmers are adopting the practice.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Midwest

Key Theme: Water Quality, Water Protection (3)

a. *Description:* A series of field experiments were continued to address practical problems related to turfgrass production in the lawn care, golf and sports fields. The effects of eight different nitrogen programs were evaluated for the three principal cool-season lawn species grown in the cool-humid region: Kentucky bluegrass, turf-type tall fescue and perennial ryegrass. Little to no nitrogen was measured in the soil solution. Furthermore, if the current goal in lawn management is to be environmentally responsible or maintain lawn turf systems that produce the highest visual appearance with only moderate growth using the fewest N inputs, the results of this study demonstrate that this goal can be achieved by planting an improved turf-type tall fescue blend and fertilizing with relatively low, 74-123 kg N ha^{-1} yr^{-1}, N levels. Compared to Kentucky bluegrass, however, some additional mowing, particularly during the spring months may be required if turf-type tall fescue receives > 123 kg N ha^{-1} yr^{-1}. In a companion study, a Kentucky bluegrass cultivar blend fertilized with three urea sources: urea, sulfur-coated urea and polymer-coated urea showed that a high quality Kentucky bluegrass turf could be achieved with a single annual fertilization of 147 kg N ha-1 with SCU or PCU.

b. *Impact:* The results of these studies suggest that if the goal in lawn management is to produce the highest quality turf with the fewest fertilizer inputs this goal can be achieved by planting a turf-type tall fescue in the lawn and fertilizing it with 123 kg N ha^{-1} yr^{-1}. This approach maximizes visual quality of the turfgrass while minimizing the negative environmental impacts. Ultimately the goal of these studies is to provide fact-based information that practitioners and homeowners can use to maximize turfgrass quality with the fewest fertilizer inputs, thus protecting water quality and enhancing quality of life.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Midwest

Key Theme: Water Quality, Biological Diversity

a. *Description:* New research projects have been initiated on lake whitefish, an ecologically and commercially important species in the Great Lakes. The impacts of trophic food web change on whitefish recruitment by examining reproductive potential, survival, and growth through the first year of life are being evaluated. Evaluation of the population biology and recruitment dynamics of lake sturgeon in the Great Lakes are currently ongoing using both laboratory and field approaches. To date, experimental trials have demonstrated that sea lampreys can kill sub-adult lake sturgeon and have negative effects on growth.

b. *Impact:* By gaining a better understanding of the influence of environmental conditions on the population biology of Great Lakes fishes, critical information will be provided for the development of management

and rehabilitation strategies. For lake whitefish in the Great Lakes, understanding the factors that influence growth, reproductive potential, and survival will allow for the prediction of year-class strength and recruitment dynamics of these two commercially important fishes.

c. Source of Federal Funds: Hatch

d. Scope of Impact: Midwest and Great Lakes

GOAL 5. ENHANCED ECONOMIC OPPORTUNITIES AND QUALITY OF LIFE FOR AMERICANS

Overview: Purdue University researchers and Extension personnel have heavily engaged in a wide array of efforts to aid in enhancing the quality of life for the people of Indiana. The recent addition of a Vice-Provost for Engagement and associated support staff has substantially increased Purdue University's role in developing information resources, services, and opportunities to facilitate the development of the state's human capacity, generating employment opportunities, and contributing to economic growth. This is a top priority at Purdue University with direct leadership from the Office of the Provost. The former Dean of Agriculture serves as the Vice-Provost for Engagement with responsibilities to extend all university educational resources to the citizens of Indiana.

Several ethanol and biodiesel plants are either under construction or in final planning stages. The New Ventures Team is helping citizens develop business plans for direct marketing, agri-tourism, and community kitchens to help small farmers process produce under sanitary conditions. Educational programs also focus on value-added and niche market opportunities for specialty crop and livestock enterprises.

Successes:

- Less stressed or less neurotic people tend to live longer.
- While fast food restaurants are frequently accused of contributing to poor nutritional choices, consumers, in fact, generally are served and consume larger meal portions in sit-down restaurants since when they order they have less control over portion sizes.

Benefits:

- Among newly-weds, and the first years of marriage, African-American women tend to have lower martial well-being scores than European-Americans, and consequently more health problems.
- An Index of Relative Rurality helps identify regions with educational deprivation and brain drain.

State Assessment of Accomplishments:

The many activities under this goal are addressing Indiana's needs in terms of improving the quality of life for the citizens in the state. Purdue University researchers have demonstrated approaches to be used by communities to make better decisions about policies that affect families. Also Purdue University scientists, working with county extension educators and many state and local stakeholders, are providing information on alternative planning and zoning. Expansion of the agricultural sector in Indiana, especially livestock and biofuels, is both creating economic opportunity and community controversy relative to land use and environmental quality.

Resources:

Approximately $ 278,192 Federal formula funds and $ 2.56 million of state funds plus 18.79 FTEs have been invested in Goal 5. These are best estimates and are not presented as auditable numbers.

5A: Improved Quality of Life

Key Theme: Aging (1)

a. *Description:* The focus of this research is on behavioral and psychological precursors to illness and mortality. Persons who declined the most in neuroticism over a 12-year period lived longer than those who remained stable or increased on this trait. The underlying mechanisms that drive this effect may have to do with the fact that persons high in neuroticism experience more stress than those low on the trait, but that health behaviors may also play a role. New analyses in 2005-06 revealed an interaction between neuroticism and widowhood on mortality. Those who were high in neuroticism and experienced the common late life stressor of widowhood had much higher mortality than those with simply one or the other of these risk factors. These findings continue to elucidate the link between behavioral and psychological factors and physical health and mortality.

b. *Impact:* This information can potentially be used to identify which individuals are most likely to benefit from stress-reduction and stress-management therapies. Those who decline on the personality trait of neuroticism live longer then those who remain stable or increase. Those who are already low in this trait live longer to begin with, and would not benefit from stress-reduction or stress-management therapies. However, those high in the trait may benefit, with the end result being better quality health and longer life.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

Key Theme: Children, Youth, and Families at Risk (1)

a. *Description:* This research explored the influences of race and gender on the marital well-being trajectories of African-American and European-American newlyweds. Several significant findings were discovered. First, the initial marital well-being scores of African-Americans are not only significantly lower than those of European-Americans, but their marital evaluations decline more rapidly than European-Americans over the first four years of marriage. Additionally, the marital evaluations of African-American women are lower than any other race x gender group examined. Because positive marital evaluations are linked to positive health outcomes, the finding that the marriages of African-Americans, particularly African-American women, decline more rapidly than other groups could contribute to health disparities in marriage. Preliminary results also reveal that household composition has a greater effect on the health and well-being of European-American women than African-American women.

b. *Impact:* Racial and cultural factors influence the health and well-being of ethnic minority groups, such as African-Americans.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

Key Theme: Parenting (1)

a. *Description:* Recruitment for the first round of data collection on child-mother relationships has been completed. Eighty child-mother dyads have been observed at home and at a playground (2-2.5 hours each time). Descriptions of both mother and child behavior have been obtained, as well as information on children and mother narratives concerning child-mother relationships. Thirty nine dyads have been seen again 12-18 months later. Similar information to the first round was collected during the second round of data gathering.. Analyses conducted on the data gathered during the first round indicate that the way mothers organize information regarding child-mother relationships (assessed through a narrative technique) is significantly related to their behavior during interactions and the quality of care they provide. Also, preschoolers budding narrative representations about child-mother interactions are significantly related to their behavior during child-mother exchanges. These results tie a specifically proposed information structure concerning child-mother relationships to actual behavior in both children and mothers. Further, analyses indicate that the quality of maternal care during the pre-school years is significantly associated to the organization of child attachment behavior.

b. *Impact:* These findings contribute to our understanding about the development and stability/change in child-mother relationships. First, they help clarify the way knowledge about attachment relationships is organized and represented mentally, and its association with the organization of child attachment behavior. Second, they contribute to our understanding of the relations between the organization of maternal information/knowledge about attachment and how they instantiate their care-giving practices. Third, they provide empirical support to the notion that continuous quality of care (during the pre-school years) is necessary for children to exhibit security in their relationship with their mother. The results obtained have implications for prevention and intervention programs aimed at improving child-parent relationships.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* United States

5B: Individual, Family and Community Economic Development

Key Theme: Workforce Preparation – Youth and Adult (1)

a. *Description:* This research developed a rurality measure, referred to as Index of Relative Rurality. The index is based on four dimensions: population size, density, percentage of urban residents, and distance to the closest metropolitan area. The index is continuous and thus does not suffer from problems that arise when using thresholds to separate discrete categories. Applying the index to an analysis of educational deprivation in the United States exemplifies how the index of relative rurality can be advantageously utilized when assessing rural-urban differences in social indicators. Using aggregate census data, the research traces spatial differences in educational attainment over space and time in the Midwest, with a special emphasis on Indiana. The research shows that the Midwest has participated in the educational boom that led to a nationwide increase in educational attainment levels. All states in the region increased their college-educated population while decreasing their population without a high school degree. However, on average, seven of the nine states are lagging behind the nation, the gap has been widening over the last three decades, and many counties have become trapped in severe educational deprivation. The research also identifies the emergence of knowledge agglomerations. Preliminary results suggest that the most important factor favorably

influencing a county's growth of its highly educated population is the proximity to other counties with a well-educated population. In contrast, rurality has a negative effect on the growth of a county's highly educated population. Using micro-level data, the research investigated the migration behavior of the highly educated in the United States. Logit models were estimated to reveal the locational preferences of the highly-educated belonging to different life course stages. Those who are young and childless are very mobile, thus being the main source of brain drain. Interestingly, they are particularly prone to leaving areas that do not offer sufficient recreational opportunities and cultural amenities. Many Midwestern areas are suffering from a brain drain as they are losing their young, highly educated population. The loss of brain power is, however, not equally distributed across space. Rural areas are particularly hard hit, and are losing their young, educated workforce at a fast rate. The research also investigated whether these differences can be blamed on income disparities between rural and urban areas. Using the 2000 PUMS data for Indiana, Illinois, Iowa and Ohio shows that --controlling for personal and job characteristics-- earned income decreases with increasing rurality. However, when decomposing the overall negative rurality effect into attribute-specific rurality effects, the results show that rurality does not universally act as an income-reducing factor. Instead, for some population groups, e.g., physicians in Indiana, increased rurality is estimated to increase income.

b. *Impact:* The newly-developed Index of Relative Rurality contributes to the ongoing debate on the concept and measurement of rurality. Identifying the factors that influence the agglomeration of human capital plays a pivotal role when designing sound regional development strategies. In this context, it is particularly important to identify the factors propelling the brain drain, which eventually may create places void of intellectual capital. Finally, by uncovering pockets of educational deprivation as well as the trajectories that lead to educational deprivation, this research helps target areas in need of improved access to education.

c. *Source of Federal Funds:* Hatch, United States Department of Commerce

d. *Scope of Impact:* Midwest

Key Theme: Consumer Management

a. *Description:* Previous research found that the nutritional quality of food that consumers choose in sit down restaurants is on average worse than food obtained at non-fast food restaurants. The reason is that the nutritional content of food from both types is worse than home prepared food, and people eat more and, hence gain more calories when dining at table service than at fast food restaurants. This is true despite the problem of so-called super sizing. It was found that while the average size of items purchased at fast food restaurants is larger, fewer items are purchased. It is reasonable to believe that this is due to the fact that consumers must pay for each item separately, and because they have reasonably accurate knowledge of the sizes being purchased. In table service restaurants, this is much less likely. Consumers often do not know how much food they are buying until the meal is served. Sizes have been increasing, and published research has shown that consumers tend to eat more when served more.

b. *Impact:* There is no doubt that consumers' food choices play a significant role in health and well being, a fact underscored by the growing problem of obesity. Much blame has been leveled at the restaurant industry, about which there is much negative publicity. Much of this is leveled at fast food restaurants and their tendency to super size. This research has shown that consumers tend to eat more

when dining at table service restaurants than at fast food restaurants. This is true of children as well as adults. The reason is that while sizes are indeed larger at fast food restaurants, fewer individual items are purchased. One reason is that consumers know the sizes when they purchase them. This is less true at other restaurants, where consumers have less knowledge of the total size of the meal. This suggests efforts to increase nutrition information about restaurant should certainly not be confined to fast food chains.

c. Source of Federal Funds: Hatch

d. Scope of Impact: United States

B. STAKEHOLDER INPUT PROCESS

Engaging stakeholders is a high priority for Purdue University. The Purdue University Strategic Plan approved by the Board of Trustees in November 2001, and now in its final year, makes it very clear that engagement with local, state, national, and world audiences is one of the primary missions of everyone at Purdue University. In the Colleges of Agriculture, Consumer and Family Sciences, and Veterinary Medicine, faculty and staff engage stakeholders on a daily basis through a wide array of activities occurring both within the university setting and across the state and Nation. About one-fourth the faculty in the College of Agriculture have a joint appointment in research and extension. These faculty have extensive interaction with stakeholders through scheduled meetings, on-farm research, problem solving consultations, field days, conferences, workshops, commodity organizations, etc. Purdue University is reaching new key stakeholders as evidenced by the hundreds of people attending annual horticultural and turf management conferences. In fact, these "green" industry events now attract more participants than the more traditional agronomy field days. Recent events include Extension programs on niche markets and organic farming and educational programs on Asian soybean rust co-sponsored with the Indiana Soybean Alliance. Several of Purdue University's Centers and Institutes that conduct research have external advisory boards which provide input and guidance on the vision for and needs of various sectors of agriculture, including agribusinesses, food processors, state agricultural organizations, and government agencies. Examples include industry advisory boards for the Department of Food Science and the Crop Diagnostic Training Center associated with the Departments of Agronomy, Entomology, and Botany and Plant Pathology. The Center for Food and Agricultural Business trains more than 1,000 agribusiness leaders annually with over 100 days of programmed events. Participants complete a written evaluation for every program. In August 2006, U.S. Senator Richard Lugar and Purdue University President Martin Jischke co-hosted a standing-room only Energy Summit on the West Lafayette campus. The College of Agriculture provided major leadership and input into this event on biofuels.

Another way our faculty and staff remain engaged with stakeholders is through a highly diverse group of organizations that involve producers and citizens with interests in agriculture and natural resources. Purdue University faculty and administrators act as *ex-officio* members or liaisons with 14 of these organizations. These groups are diverse, meet regularly, and are often focused on a particular interest, providing us with an excellent way to interact with a wide cross-section of agriculture interests. The Director and Associate Director of Agricultural Research Programs are both members of the Agricultural Alumni Seed Improvement Association Board of Directors. This facilitates the release of public varieties of wheat, oats, and soybeans as well as germplasm. The Associate Director serves as the liaison with the Indiana Soybean Alliance and the Indiana Pork Producers Association. This provides an excellent opportunity to showcase Purdue research efforts related to biodiesel, livestock rations that utilize co-products from biofuels production, and science-based information to facilitate the expansion of the Indiana livestock sector in an environmentally sensitive manner.

The Department of Foods and Nutrition in the College of Consumer and Family Sciences has frequent meetings with a Corporate Affiliates Advisory Board. The Department of Food Science has an Advisory Board composed

of executives in the food processing sector who periodically meet on campus. The Department of Agronomy, in collaboration with the Office of Agricultural Research Programs, hosted an all-day Cropping Systems Listening Session in April 2006 with key farm and agribusiness leaders to help shape the direction of future research and extension efforts. In December 2006,the Department of Animal Sciences held a series of listening sessions with key livestock rganizations.

The College of Agriculture convenes annual meetings with several different stakeholder groups. These often involve direct solicitations of input from participants. A few examples are described below.

Purdue Council for Agricultural Research, Extension, and Teaching

The Purdue Council for Agricultural Research, Extension, and Teaching (PCARET) organization exists throughout Indiana. Multi-county meetings involve a broad base of stakeholders, plus Purdue University administrators. At the county level, the committee members are identified by current PCARET members, county extension staff and the County Extension Board. County committees elect representatives to the area committee. Area committees elect state leadership. PCARET membership spans a wide range of occupations and interests, including school teachers, livestock and crop farmers, and local business leaders.

PCARET holds regional meetings throughout the state in both the spring and fall. At every meeting, representatives from the College of Agriculture attend to update PCARET members on state and national legislative initiatives and programs. An annual meeting for all PCARET members was hosted on the Purdue University campus in November 2006. Indiana has one of the most active and effective CARET organizations in the United States.

Dean's Advisory Council

The Dean's Advisory Council is made up of representatives from primary and secondary education, producers, farm input industries, banking, agricultural and community associations, the state legislature, environmental organizations, and others. Members are chosen by the Dean with input from the Department Heads. The primary purpose of the Dean's Advisory Council is to provide broad clientele input to the Dean and Associate Deans for Research, Teaching, and Extension. The Dean's Advisory Council meets twice a year. This offers an excellent sounding board for ideas with a wide array of diverse clientele. In a recent session the emphasis was on the educational needs of society in the 21st Century.

College of Agriculture Strategic Plan

Purdue University has developed, and the Board of Trustees has approved, a Strategic Plan for the entire University. The College of Agriculture completed in 2002 a roadmapping activity to lay out a Strategic Plan for reaching "the next level" in learning, discovery, and engagement. Stakeholders from around the state were invited to join administrators and selected faculty at a daylong retreat that kicked off the roadmapping effort. There were subsequent opportunities for feedback from stakeholders as the plan evolved. The College of Agriculture's Strategic Plan has been approved by the Office of the Provost. Each Department in the College of Agriculture has completed a department-level strategic plan which was submitted to the Dean of Agriculture. Individual departments sought input from their various stakeholders as they developed their strategic department plans. This information also is included in the 5-year USDA-CSREES departmental review process.

The Purdue University Strategic Plans calls for hiring 300 additional faculty over five years.Purdue University is in the final year of this Strategic Plan and anticipates reaching the goal of 300 new faculty in 2007. The Colleges of Agriculture, Veterinary Medicine, and Consumer and Family Sciences are all benefiting from these new faculty

hires. To date about 40 new faculty have been hired in these three Colleges out of an expected allocation of about 45. Priority is being given to three criteria: 1) replacement of Teaching Assistants (TAs) with faculty, 2) cluster hires to focus research and extension expertise on key problem areas where there is a priority need expressed by stakeholders plus funding opportunities, and 3) diversity sensitivity. Nearly one-half of the new faculty hires represent women and/or minority hires. This will help Purdue University better reflect the profile of stakeholders that we serve statewide. During 2006, there was substantial progress made in making cluster hires that encouraged cross-campus, interdisciplinary research efforts. This is expected to generate additional extramural research funding and help support the Discovery Park research complex. Several Centers in Discovery Park involve faculty in the College of Agriculture including bioenergy, nanotechnology, life sciences, entrepreneurship, and environmental sciences.

Purdue University expects to hire a new President in 2007. Dr. Jischke announced his retirement in 2006. A new Strategic Plan will be developed at the University, College, and Department levels in the years ahead. Stakeholder input will play a key role in this planning process. This will also coincide with the implementation of the new USDA - CSREES Plan of Work.

Indiana Crop Improvement Association

Purdue University has a very close working relationship with the Indiana Crop Improvement Association. Faculty are speakers at their annual meeting and share in program planning. There has been a significant collaborative research effort over the past few years that has resulted in the development of CystX™. CystX™ technology can genetically transform soybeans to be resistant to the cyst nematode, a serious soil pest problem in much of Indiana, and the Midwest, that reduces soybean yields. Some elite soybean varieties were available for planting in 2006, and many more are expected to become available during the next few years. This should help Indiana growers manage the cyst nematode problem and increase soybean yields. Check-off funds through the Indiana Soybean Alliance also have helped finance this effort. This is an excellent example of collaboration among various stakeholders and Purdue University scientists to resolve a major Indiana crop management problem.

Indiana Plant Food and Agricultural Chemical Association

The Indiana Plant Food and Agricultural Chemical Association is composed of individuals from the agricultural input community in Indiana. A typical member sells agricultural chemicals or fertilizers or manages a retail operation. A Purdue University faculty member serves on the board of directors of the Indiana Plant Food and Agricultural Chemical Association in an *ex-offico* status. Meetings of the Indiana Plant Food and Agricultural Chemical Association Board of Directors are held monthly where ideas and issues are discussed. The group also has an active email list and web site where information is exchanged. Individuals from this group also serve on the Advisory Board of the Crop Diagnostic Training Laboratory which offers educational programs to crop protection professionals. Most of the efforts are carried out at the Agricultural Crop and Research Education farm located near campus. The Beck education building currently under construction will permit year-round Extension and professional educational opportunities with the crop protection industry and others.

Indiana State Department of Agriculture

In 2005 the Indiana General Assembly passed legislation to establish for the first time an Indiana State Department of Agriculture. Most state regulatory functions are still located on the West Lafayette campus, e.g., Animal Disease Diagnostic Laboratory and the State Chemist's Office. The Lt. Governor serves as the Secretary of Agriculture and Rural Development. The Director and staff of the newly formed Indiana State Department of Agriculture have developed a Strategic Plan which includes seven initiatives: 1) bioenergy, 2) hardwoods, 3) farm and trade policy, 4) food processing, 5) diversity of production, 6) doubling pork production, and 7) regulatory coordination. Purdue University faculty are engaged in a variety of ways in all of these initiatives. The Dean of Agriculture, Director of Agricultural Research Programs, and other administrators have frequent contact with the

Lt. Governor's Office and other state officials. Recently, approximately $250,000 of internal grant funds were made available to faculty in the College of Agriculture to conduct critical multi-disciplinary, integrated research and extension programs closely associated with one or more of these seven initiatives. Also Mr. Chuck Connor, Deputy U.S. Secretary of Agriculture, is a Purdue University graduate. He is from Indiana and has frequent contact with Purdue University officials on a variety of agricultural policy topics.

Commodity and Farm Organizations

Purdue University has a close working relationship with various stakeholders through commodity and general farm organizations including the Indiana Soybean Alliance, Indiana Corn Growers Association, Indiana Pork Producers, Indiana Wine and Grape Council, Indiana Poultry Association, Indiana Mint Growers, Indiana Turkey Council, and the Indiana Farm Bureau. Administrators serve in various *ex-officio* capacities with these organizations. With some, such as the Indiana Farm Bureau, Purdue University faculty and administrators have biennial meetings with the elected Farm Bureau leadership and staff to discuss topics of mutual interest such as agricultural research priorities, state funding support, land use planning, biotechnology, agricultural policy, and local community policy issues. Tours of research facilities are frequently organized for Directors and staff of these organizations.

C. PROGRAM REVIEW PROCESS

The Office of Agricultural Research Programs manages the research portfolios on the principle of one research project per investigator in many cases, but team-based research projects are encouraged and growing in importance. Every Peer Review Panel includes faculty from at least two different disciplines. Research collaboration among faculty across departments, colleges, and universities in other states is strongly encouraged. Project proposals are reviewed as described in the Plan of Work. After rigorous review on campus, nearly 100% of the projects sent to USDA- CSREES National Program Leaders have been approved. As in past years, for FY2006 100% of the faculty again completed prior to the February submission deadline their annual CRIS reports—a total of 350 CRIS reports including USDA-NRI grants and multi-state projects. This CRIS information is used for reports to the Dean of Agriculture, the Office of the President of Purdue University, and through the Department of Agricultural Communications the development of Press Releases and other stakeholder oriented publications.

D. EVALUATION OF SUCCESS OF MULTI AND JOINT ACTIVITIES

In 2006, 120 faculty associated with the Office of Agricultural Research Programs at Purdue University were involved in 116 multi-state projects managed through the four Regional Experiment Station Executive Directors' Offices. These multi-state projects have a broad disciplinary base. All these multi-state research projects are relevant to one or more of the five USDA-CSREES goals. The Office of Agricultural Research Programs reimburses the travel expenses for those faculty associated with each approved multi-state research meeting. Multi-state funds are also allocated to the various departments to help defer research costs associated with these approved projects.

The following are representative examples of the breath and depth of the involvement of Purdue University faculty from multiple disciplines who were engaged in various multi-state research projects throughout the United States during fiscal year 2006.

Management of Grain Quality and Security for World Markets

A multidisciplinary team from Purdue University composed of two agricultural engineers (Drs. Maier and Stroshine), an entomologist (Dr. Mason), an agricultural economist (Dr. Alexander), and a plant pathologist

(Dr. Woloshuk) have contributed to a multistate project on grain quality (NC213). The primary goals of this project are to (1) quantify the benefits of tempering on single kernel moisture content and stress crack development of corn using data collected in a small prototype continuous-flow dryeration (CFD) unit, (2) use the experimental results to modify and validate an existing computer simulation model, and (3) scale-up and optimize the CFD system for typical on-farm and elevator applications, quantify energy savings and develop recommendations for future implementation. The experimental tempering results indicated that tempering reduced stress cracks up to 100% and moisture variability by 55 to 73% with the greatest reduction observed during the first four hours. Several concepts were evaluated that could be utilized for a full-scale continuous-flow dryeration system. Commercially available hopper bins could be modified to incorporate a cooling section in the bottom and a tempering section in the top portion of the bin. The cooler model predicted the moisture removal for a typical on-farm and elevator CFD system. The results indicated that the optimum elevator and on-farm applications removed up to 1.9 points of moisture from a hot grain moisture content of 17% (w.b.). It was also determined that the CFD system could reduce drying costs by up to 10.3% while increasing drying capacity by up to 36%.

Impact: Based on the results of this research, continuous-flow dryeration systems can be designed and built to meet the growing needs of producers and elevator managers to increase drying capacity of existing systems, while maintaining grain quality, reducing drying costs, and reducing energy consumption. Annual national meetings have involved various grain industry stakeholders.

Evaluating the Physical and Biological Availability of Pesticides and Pharmaceuticals in Agricultural Contexts

Society is concerned about excessive use of veterinary pharmaceuticals in confined animal feeding operations (CAFOs). Drs. Lee and Turco (an environmental chemist and a soil scientist) are contributing to a multistate project which is investigating potential soil and water contamination from livestock feed additives such as hormones and antibiotics (W1082). Sorption and aerobic degradation studies with cobalt-radiated (sterile) and untreated soil systems were conducted for a synthetic androgen used in the beef industry (trenbolone isomers) and its primary metabolite (trendione); and two ionophore antibiotics monensin and lasalocid common to CAFOs and their primary metabolites. The two alpha and beta isomers of trenbolone appear to follow similar degradation pathways. Degradation is primarily, but not completely, microbial, and concentration-dependent rates were observed. At applied concentrations of 1 mg/kg, half lives ranged from 5-14 hours whereas at applied concentrations of 10 mg/kg, half lives increased to 2-3 days. Some concentration dependence seemed apparent for trendione as well with half lives ranging from 3 to 4 days. Degradation of trendione generated from trenbolone was well predicted using rates estimated from independent trendione degradation studies. Hormones in manures excreted by cattle implanted with Ravoler-S (140 mg TBA and 28 mg estradiol) were monitored. Manure from the pits was sampled after mixing immediately prior to flushing to lagoons, which were sampled every 2 weeks starting with the 4th week after implanting. Trenbolone exhibited the highest hormone concentration in both the manure (> 2 ug/L) and the lagoon (> 0.12 ug/L). Hormone concentrations in cell 2 were the greatest at 4 weeks after implants, but below 0.03 ug/L except for trendione (~ 0.14 ug/L). For the ionophore antibiotics, organic carbon normalized sorption coefficients (log Koc) ranged from 1.53 - 3.67 for monensin and 2.89 - 4.30 for lasalocid and were negatively correlated with soil equilibrium pH. Degradation was measured in moist sterile and unsterile soil microcosms at 23 C and 0.03 MPa moisture potential. Microbial degradation of both antibiotics occurred rapidly in soils with and without manure amendments with half lives of 1 to 2.1 days for monensin and 1.8 - 4.3 days for lasalocid. Preliminary testing of surface water and beef lagoon effluents showed monensin in the aqueous portion of the beef lagoon sample was found to be 40 ug/L, while the suspended solids fraction

contained 2000 ug/kg. The monensin concentration in a nearby drainage ditch was found to be 0.1 ug/L in the aqueous fraction and less than the method detection limit of 0.5 ug/kg in the sediment.

Impact: Antibiotics and synthetic hormones used in animal production are excreted in the urine and feces, which are commonly injected into agricultural fields after an incubation period in a manure pond. Although trenbolone has been reported with a half life of nearly one year in anaerobic manure pits, once applied to soil it appears to degrade rapidly. Likewise, several antibiotics known to persist in an anaerobic environment (manure or lagoon bottom) appear to degrade rapidly once applied to soils. Research on tetracylcines, tylosin, carbadox, monensin, and lasalocid indicates that when these compounds are applied to soil will degrade rapidly, and only low levels at most are likely to be observed in nearby water bodies.

Methods to Increase Reproductive Efficiency in Cattle

Dr. Krisher's (a reproductive physiologist) contribution to NC1006 is to examine the effect of routinely used superovulation and estrous synchronization protocols on oocyte developmental competence. Gene expression is being measured both *in vitro* and *in vivo* using oocyte metabolism as markers of oocyte competence and viability. Candidate genes have been identified via microarray projects in mice and cattle that have identified specific genes that appear to be influenced by oocyte developmental competence.

Impact: From these studies it will be possible to understand, for the first time, how manipulation of follicular growth in cattle impacts oocyte competence. Using this information, current protocols can be modified or new protocols developed for manipulation of reproduction in cattle that suport oocyte developmental competence, thereby increasing pregnancy rates, reproductive efficiency, and producer profitability.

Advanced Technologies for the Genetic Improvement of Poultry

The poultry industry is interested in more cost-effective breeding techniques. Dr. Muir (an animal geneticist) is assisting with the implementation of marker assisted selection in this multistate project (NC1008). For traits of low heritability, initial theoretical examination showed that marker assisted selection could increase response to selection by as much as 500%. However, a decade of experimentation and simulations has since demonstrated a much more moderate response. These short comings were found to be due to a critical assumption: that the quantitative trait loci (QTL, or closely linked makers) affecting such traits were known. In actuality, these QTL associations are found by statistical estimation and hypothesis testing based upon similar data breeders would use to make selection decisions, i.e., have the same limitations of a high environmental variance. Thus, QTLs for traits of low heritability are difficult or impossible to locate. Using genome-wide marker assisted selection, the more generations of training you do, the better it is at prediction. For a trait of heritability of .5, the accuracy of selection with genome-wide marker assisted selection reached about 88%. For a trait with a heritability of .1, the accuracy of selection is up to almost 70% with genome-wide marker assisted selection and three generations of training. For the future of genomics in animal breeding, the only real issue is to reduce the cost. Note that the object of this method is not gene discovery. The goal is predicting the best breeders. If gene discovery is one of the primary goals of genomics, rather then increasing response to selection, then genome-wide marker assisted selection may not be the best choice.

Impact: After two decades of waiting for the promise of biotechnology in animal breeding program, the light is starting to shine. Simulations show for the first time that genome-wide marker assisted selection, where dense selection markers are used across the genome, exceeds classical breeding for all heritabilities

and can be used for all traits. The only real issue is to reduce the cost. The current 4 cents per genotype is still 40 times too high for many applications, but this cost is expected to hit an applications goal of 0.1 cent per genotype in the next few years due to technological advances.

Dynamic Soybean Pest Management for Evolving Agricultural Technologies and Cropping Systems

On an alternating year basis (2001, 2003, 2005) soybean aphids have become a major invasive species in soybeans in the upper Midwest. This regional project (S1010) with the contribution of three Purdue University entomologist (Drs. O'Neil, Krupke, and Bledsoe) has explored the soybean aphid's natural enemy interactions by focusing on the dynamics of the soybean aphid, its predator, Orius insidiosus, and an alternative prey, soybean trips. Based on a comparison of aphid population growth in the field and in exclusion cages, and from a survey of the different predators present in the field, it has been shown that the soybean aphid populations can be significantly limited by natural enemies in the field. Moreover, there is a significant negative correlation between aphid population growth and Orius insidiosus abundance, while no correlation appears between aphid population growth and other generalist predators present in the field. There is no correlation between aphid population growth and degree-day during the summer. The spatial distribution of aphids among plants had an impact on the effect of O. insidiosus on aphid population growth. Aphid population growth was lower when the aphids were in a clumped distribution rather than random. Plant size appears to mediate this effect such that as plant size increases, the relative size of clumped populations decreased. No effect on the random populations is evident. The dynamics of O. insidiosus are not dependent on soybean aphid densities, but are driven to a large extent by thrips dynamics. The numerical response by the predator to thrips is reproductive rather than aggregative at the field level. The earlier the predator arrives relative to soybean aphid arrival, the lower was the peak soybean aphid density per plant in that field during the season.

Impact: Improved understanding of the driving mechanisms of soybean aphid dynamics will provide pest managers better options to control the pest. The contribution of predators to soybean aphid dynamics is critical to its pest status. This research will help define the key components of the aphid-predator dynamic in the field, and may result in a successful bio-control rather than insecticide solution to the soybean aphid invasion in recent years.

Managing and Marketing Environmental Plants for Improved Production, Profitability, and Efficiency

Dr. Dennis, who has a joint appointment in horticulture and agricultural economics at Purdue University, has contributed to this multi-state project (S1021) by conducting an Internet survey to evaluate and determine differences in gardening participation, purchases, and levels of satisfaction and regret by ethnic background. Consumers were asked to identify their participation in seven gardening activities and indicate their purchases in 12 gardening product categories.

Impact: This research provides consumer behavior insight for horticulture producers and retailers. For example, the ethnic gardening study has shown that gardening participation and purchases decreased as income increased across ethnic groups. For marketers, this suggests a heterogeneous market at lower-income levels, but a more homogeneous market at upper-income levels. Ethnicity could be used as a basis for market segmentation.

Nutrient Bioavailability-Phytonutrients and Beyond

Dr. Weaver (human nutritionist and world expert on bone density and calcium absorption) has actively participated in this multi-state project (W1002). Suppression of bone resorption in postmenopausal women by various commercial preparations of isoflavones was analyzed with a novel method using calcium-41.

Impact: Phytoestrogens are being marketed as an alternative to estrogen therapy for preventing bone loss in postmenopausal women without sufficient evidence of efficacy. Isoflavone preparations from soy cotyledon, soy germ, kudzu, and red clover were compared to estradiol and bisphosphonate for suppressing bone resorption. The soy cotyledon preparation suppressed bone resorption by 18% compared to approximately 25% suppression by estradiol and the bisphosphonate. No other product was effective at reducing bone loss.

F. Integrated Research and Extension Activities (Brief Summaries Follow)

U.S. Department of Agriculture
Cooperative State Research, Education, and Extension Service
Supplement to the Annual Report of Accomplishments and Results
Actual Expenditures of Federal Funding for Multistate Extension and Integrated Activities
(Attach Brief Summaries)

Fiscal Year: 2006

Select One: ☐ **Interim** ☐ **Final**

Institution: Purdue University

State: Indiana

	Integrated Activities (Hatch)	Multistate Extension Activities (Smith-Lever)	Integrated Activities (Smith-Lever)
Established Target %	5% **%**	5% **%**	5% **%**
This FY Allocation (from 1088)	4,664,640	8,149,959	8,149,959
This FY Target Amount	$233,232	$407,498	$407,498
Title of Planned Program Activity			
Innovations in Handling Large-Scale Animal Mortalities		$ 12, 683	
Demand for Certified Meat Products	44,203	23,087	23,087
Purdue University's National Software For Nutrient Management Planning		$27,542	
Indiana's Certified Crop Advisers Maintain Their Edge		68,965	
Impact of the 15th Annual Tri-state Dairy Nutrition Conference	19,427	54,628	
Impact of Dietary Manipulation on Odors and Gases from Swine Facilities in both Research and Field Setting		45,711	45,711
Reduction of Laying Hen Emissions		28,081	28,081
Delivery of a Weather-Based Spray Advisory Program to Illinois and Indiana	20,220	49,606	
Emerald Ash Borer Awareness	9,516	25,413	
Improving Quality of Indiana's Apple Crop	12,642	22,596	
Opportunities, Challenges, and the future Role of the U. S Crop Input Dealer	15, 635		58, 630
Agricultural Innovation and Commercialization Center	23, 318		4, 467
Crop Management Practices in Indiana Soybean Production Systems: A grower Survey	3, 788		103,464
Time Spent Selecting Forages is Important	12, 420		65,633
Drainage, Tillage, and Cover Crop Effects on Soil Properties and Corn yields	41, 800		17,204
Diet Modifications to Reduce Nutrient Excretions in Swine Operations	58,298	45,711	45,711
Increasing the Consistency and Predictability of Beef Products for Target Markets through Pre-Harvest Nutrition and Management	6,258		
Identity-Preservation Systems for Value-Added Quality Grains	23,549		
Corn, Soybean, and Soil Quality Responses to Alternate Cropping Systems	3,441		
Impact Title Turkey Nutrient Excretion and Volarization	9,674	28,081	28,081
Biology, Management and Distribution of Glyphosate Resistant Horseweed (Conyza canadensis) and Other Weeds	54,384		73,715
Total	$261,613	$419,421	$430,687
Carryover			

Certification: I certify to the best of my knowledge and belief that this report is correct and complete and that all outlays represented here accurately reflect allowable expenditures of Federal funds only in satisfying AREERA requirements.

Director

___03/21/2007_____
Date

F. INTEGRATED RESEARCH AND EXTENSION ACTIVITIES BRIEF SUMMARIES

The following are representative examples of integrated research and extension activities conducted by Purdue University faculty and staff during the past year.

Opportunities, Challenges, and the Future Role of the U.S. Crop Input Dealer

Retail crop input dealers have played an important role in the distribution channel for fertilizer, crop protection chemicals, seed, and agronomic services for decades. However, consolidation at the manufacturer and farm level, new crop production technologies such as genetically modified seed, new information technologies utilizing the Internet, and new

competitors have all combined to challenge the traditional roles that retail crop input dealers have performed. These firms have been important local employers in many areas. Many of these firms are independent businesses or farmer-owned cooperatives. As retail crop input dealers develop longer-term strategies, information on what the future may hold can be extremely useful. This study explored how retail crop input dealers perceive their future: where are the opportunities; where are the challenges; and what roles do they expect to play in the future? More than 300 retail crop input retailers across the United States responded to a survey. The focus of this survey was two-fold: 1) to explore what crop input dealers believe to be the major opportunities and threats facing their firms over the next three years; and 2) to better understand how managers of these firms believe their firm's role in the distribution channel will evolve over the same period. The information has been distributed to the industry through a series of magazine articles, a staff paper, through presentations to trade groups, and an M.S. thesis.

Impact: Key findings suggest that 1) most dealers see their top challenges as internal issues such as insurance costs, access to quality employees, and energy costs; 2) the most important opportunities tend to be product and service focused, and are related to traditional sources of revenue, including seed sales, traditional agronomic services, and precision farming services; 3) dealers see their future sales and profit mix as including more seed, service, and information sales, with less sales and profit coming from fertilizer and crop protection chemicals; and 4) most dealers see current high profile roles for both farmers and manufacturers becoming more important in the future, with an increased role in helping farmers comply with government regulations and providing on-going crop management services for farmers, and an increased role in tracking crop input use for regulatory purposes for manufacturers.

Demand for Certified Meat Products

Consumer demand for process verified products appears to be rising, however it is unknown whether consumer willingness to pay exceeds the costs of certifying compliance with process standards. In addition, it is not clear to what extent markets will expand to increase market access for farmers who see dwindling alternatives in the marketplace. The willingness to pay for natural pork products was estimated based on a consumer survey. It was found that there is the potential for market expansion with the introduction of such certified natural pork products.

Impact: The results of this analysis suggest that there is a large segment of consumers (~43%) who have substantial willingness to pay for antibiotic free, environmentally friendly, and animal welfare certified pork. The results suggest that as much as 62 % of the market could transition to such a product in the long run. Members of the farm community and groups of farmers are beginning to examine the development of standards for similar products. The details of developing standards and the strategies associated with launching such new products are being discussed with interested producer groups. The analysis was developed into a pilot business plan by the Agricultural Innovation and Commercialization Center (funded by a USDA grant) at Purdue University as a model for marketing a process as a product attribute.

Agricultural Innovation and Commercialization Center

Two groups of businesses are vital to economic prosperity of Indiana. New business ventures are important sources of economic growth. In addition, small businesses represent a critical component of the economy. However, because entrepreneurs exploring new business ventures get very excited about their new business idea they often do not conduct the appropriate analysis before making the business investment. The result can be poor investments that end as expensive failures. Existing small business owners often don't conduct the necessary analysis for business investments they are making. Easy to use and accessible business planning tools are needed. In addition, education for potential entrepreneurs and small business owners is needed. Educators at Purdue's Agricultural Innovation and Commercialization Center were awarded one of ten $1 million USDA grants to assist entrepreneurs with new business development. InVenture is a practical business planning tool that guides entrepreneurs through the business planning process in stages. In each of the stages the entrepreneur answers the key questions that guide the business creation process. The entrepreneur's work becomes a business plan that may be taken to potential partners or investors. A series of 22 publications are available to assist entrepreneurs with the different stages of business planning, from setting goals, to determining necessary licensing requirements, to developing a marketing plan, to doing financial projections for potential lenders. Highly successful statewide and national workshops have been delivered. In addition to virtual delivery via the website, www.agecon.purdue.edu/planner, entrepreneurs may access one-on-one assistance through Purdue's New Ventures team of Extension educators.

Impact: Purdue educators looking for ways to assist in economic development have created InVenture, a useful web-based tool for entrepreneurs, along with a set of 22 publications and statewide and national workshops. InVenture has over 1200 registered users from Indiana and around the United States. The statewide and national workshops have been delivered to over 1100 participants and has been very well received. Participants noted that they "have not stopped talking about the enjoyment, satisfaction and usefulness we will get from attendance." They were "very impressed with the amount and quality of resources available to Indiana entrepreneurs" and described the program as "truly refreshing and gratifying." In addition, participants indicated that they had "not been able to find resources like these, so the material was invaluable!"

Crop Management Practices in Indiana Soybean Production Systems: A Grower Survey

To remain economically viable in today's global soybean market, Indiana producers' require instant access to cutting edge innovations, information on new and potential pest problems, and timely, accurate information on common soybean production problems. The goal of this project was to aid Purdue Extension and research faculty in identifying and developing Extension programs and educational materials that meet current and future clientele needs, and to provide a framework for directing applied soybean research efforts. The specific objectives were: 1) to identify the key production concerns of Indiana soybean producers, 2) to implement research and extension efforts to address these concerns, 3) to develop baseline data to support future grant proposals, 4) to receive feedback from clientele on the best delivery media for research and extension information (web, printed guides, county/regional meetings, press release, etc.), and 5) to disseminate this information via Extension and peer-reviewed research publications. The Indiana Soybean Alliance helped underwrite this study. A seven-page direct mail survey was sent to 5000 Indiana soybean growers in August of

2005. Purdue University consulted with the Indiana Agricultural Statistics Service to develop and distribute the survey to growers representing various size farming operations and geographic regions within Indiana. For continuous measures, farm size was the treatment and the experimental design was completely randomized. Analysis of variance was conducted and least-squares means were compared by t-tests where the F test was significant A total of 1330 growers returned this survey, however, only 1310 growers indicated the size of the farm operation. This represented a response rate of 27%. The survey was divided into three sections: crop management, pest management, and marketing. Responses to each question were characterized by farm operation size and crop reporting district

Impact: Large acreage growers (>1000 acres) were more likely to plant soybeans in rows spaced 11 to 20 inches, reduce seeding rates, plant earlier, and have higher yields. Large acreage growers were also more likely to own a combine yield monitor, conduct on-farm research, use a computer, and routinely use the Internet. This research also identified different research and educational needs based on farm operation size. By specifically targeting these needs, agricultural researchers and Extension specialists should be able to help improve the economic and environmental sustainability of Indiana soybean growers.

Time Spent Selecting Forages is Important

Many forage crops are successfully grown in Indiana and surrounding states. Within a specific crop, there are many varieties that are available for purchase. Evaluation of different forages and varieties with subsequent release of the data for review by forage producers will improve the forage producing enterprise. Forage performance trials at the Agronomy Center for Research and Education (ACRE), West Lafayette, Indiana, and the Feldun-Purdue Agricultural Center (FPAC), Bedford, Indiana are providing useful information regarding the productivity of different forage crops and varieties within a specific crop.

Impact: Tall fescue varieties established in August 2002 at FPAC outperformed orchardgrass varieties established on the same date in accumulated dry matter yields for 2003 and 2004 by 7 percent. ‘Duo’ festulolium, a hybrid of perennial ryegrass and meadow fescue, was established within the tall fescue field trial. ‘Duo’ festulolium was the most productive variety within the trial in 2003, producing 23 percent more dry matter yield than the average of nine tall fescue varieties in the trial. However, in 2004 the dry matter yield of ‘Duo’ festuloium was arithmetically the poorest and yielded 32 percent less dry matter yield than the average of the tall fescue varieties. Performance of 'Duo' festulolium in 2005 was again the poorest of all entries. Based on results from the tall fescue performance trials at FPAC, several low-endophyte varieties are performing as well as 'Kentucky 31' endophyte-infected tall fescue. 'Kentucky 31' tall fescue was found to have a within-plant (endophyte) fungus approximately 25 years ago. This fungus is responsible for less than optimum animal performance when livestock utilize tall fescue as a feedstuff. Low-endophyte tall fescue varieties have been criticized for being less persistent than endophyte-infected tall fescue. Results from the FPAC trials and past grazing studies conducted at the Southern Indiana Purdue Agricultural Center should dispel harsh criticism about low-endophyte tall fescue. The 2002 and 2003 seeded alfalfa performance trials at ACRE indicate that statistically superior varieties where the damaging insect pest potato leafhopper was not controlled yielded, on average, only 5.5 percent less dry matter yield in 2004 than statistically superior alfalfa varieties when the potato leafhopper was controlled with the insecticide cyfluthrin.

Varieties that had best dry matter yields within the non-chemical treated trial have glandular hairs that are responsible for the reduction of damage caused by the insect pest. The small dry matter yield increase when chemical control was used has less importance when insecticide cost, application cost and costs associated with scouting the field for the presence of the insect are considered. Forage producers should review performance trial data of different crops and cultivars when making decisions regarding which species or varieties have best dry matter yield and persistence. Well-adapted tall fescue varieites produced more dry matter than orchardgrass. Many low-endophyte tall fescue varieties and potato leafhopper resistant alfalfa varieties are performing well in Indiana and should not be discriminated against as being inferior choices.

Drainage, Tillage, and Cover Crop Effects on Soil Properties and Corn Yields

The beneficial effects of cover crops, manure applications, rotations with hay or meadow crops, and conservation tillage practices on soil physical properties have long been recognized. The need for such practices is greater on soils that are poorly structured and low in organic matter than on soils that are naturally well structured and contain higher organic matter levels. If the poorly structured soil is also naturally poorly drained, however, the ability of these practices to improve soil properties and crop yield may be limited by wet or cold conditions. Installing good surface and subsurface drainage systems to mitigate the excess wetness problem may provide the opportunity to improve soil properties and crop growth with cover crops and similar agronomic practices. The objectives of this study were to evaluate the effects of five agronomic management practices (cover crops, animal manure, rotation with hay crop) and two tillage systems on soil properties and crop growth, under both drained and undrained conditions on a naturally poorly drained, low organic matter Clermont silt loam soil in southeastern Indiana.

Impact: In the tiled subfield, all agronomic treatments produced equal or higher yields than continuous corn on average, whereas on the untiled subfield they produced equal or lower yields than continuous corn. Agricultural soils with seasonally high water tables require drainage systems for efficient crop production. When linked with use of no-till practices, winter cover crops, or rotation with hay crops, soil physical properties and crop growth and yield may be improved significantly. The results underscore the necessity of an adequate drainage system as a first step to improving crop yields, and that agronomic practices alone are not likely to make up for an inadequate drainage system.

Diet Modification to Reduce Nutrient Excretions in Swine Operations

The compatibility of pork production operations with neighbors in rural America is still a major concern. When a pork operation moves into a rural community or expands an existing operation, the public often raises complaints and petitions to prevent the growth of the industry. Reasons for concern are water quality issues, including the threat of nutrient, pathogen, hormone and antibiotic contamination. In addition, air quality issues of dust, odors and gas emissions are major concerns with large concentrated pork operations. Human health concerns are paramount with these water and air quality issues. These water and air quality concerns come predominantly from manure excreted by swine within their housing units, manure storage and manure application to cropland. The pig is the first point source of generation of potential contaminants to the environment; therefore, if we can alter the diet to enhance efficiency of nutrient retention in the pig and reduce nutrient excretion and odors,

then the source of water and air contamination can be reduced. The feeding of diets that are formulated with combinations of LPA corn, reduced crude protein content, synthetic amino acid supplementation, phytase, and soy hulls (LNE) can be an effective way to reduce the environmental impact of pork production. With the feeding of these diets, significant reductions in the excretion of nitrogen, ammonium nitrogen, total phosphorus, water soluble phosphorus, and potassium were observed. Thereby, the amount of land required for manure utilization would be greatly reduced. While the potential environmental impact of swine production was reduced, the performance during the overall grow-finish period and carcass characteristics at all harvest points in most studies were maintained. Additionally, the feeding of these diets increased the efficiency of nitrogen and phosphorus over the entire wean-finish period. However, with these different lean genetic lines, it is of importance to further investigate the degree at which amino acid supplementation can occur in reduced crude protein diets without impacting performance. Additionally, there is a need to re-examine the amino acid and phosphorus requirements of today's high lean gain potential genetic lines. Feeding LNE diets in commercial settings appears to hinder growth performance, especially during the grower phase. These reductions in performance are further increased when the pigs are reared under low health conditions. While performance was reduced, carcass characteristics were maintained in two experiments when the LNE diets were consumed. Barns in which the LNE diets were fed contained 60% lower aerial ammonia concentrations than the control barns. Total manure production and water consumption were reduced with the feeding of these diets. In addition, total nitrogen and phosphorus excretion was reduced when the LNE diet was fed to grow-finish pigs. Further research is needed to better define the nutrient requirements of high lean gain potential swine, not only in research settings but true commercial settings as well. In general, the lean accretion for pigs fed LNE diet formulations peaks earlier in the grow-finish period and does not reach as high of a peak or maximal protein accretion. This may be because of under estimating requirements later in the grow-finish period, over estimating dietary amino acid availability, or may be an effect of peaking earlier in life than the control pigs. In contrast, however, LNE fed pigs have equal or lower lipid accretion and tend to peak at a later time in the grow-finish period. The amino acid levels, ratios, and availability need to be further evaluated and refined in the LNE formulations to achieve similar protein accretion rates.

Impact: The long-term objectives of this research were to demonstrate the effectiveness of manipulation of swine diets in reducing nutrients and odor production from pork production facilities. This data will be used to provide a model for producers, extension educators, regulators, consultants, and legislators to plan environmentally sound pork production systems throughout the United States. This model will also estimate the reduction in nutrient excretion, reduction in odors and gases, and predict animal performance. These data have had immediate application with pork production farms and reduced nutrient excretions and odors have been observed. Reducing nitrogenous and phosphorus compounds in the manure will allow increased application rates on fewer acres and a more balanced application meeting crop needs. By reducing odor levels leaving swine facilities, there should be less concern from neighbors and more acceptance of the pork industry in communities. Feed, fecal and urinary concentration of minerals, coupled with feed intake and body composition measurements, has allowed us to calculate mass balance for essential minerals. This tool (mass balance) has allowed us an opportunity to compare diets composed of various ingredients and diet modifiers to producers for nutrient management plans. It is well established that dietary manipulation is a very effective method to reduce the environmental impact of swine production. By using crystalline amino acids and the concept of ideal protein

reduced crude protein corn-soybean meal diets greatly reduces nitrogen excretion. By using these concepts in formulation, nitrogen excretion can be reduced 20 to 30% without influencing growth performance, carcass value or cost of production. However, the economic impact of using low nutrient excretion diets was variable due to changes in the cost of ingredients, especially for synthetic amino acids, non-sulfur trace minerals and low phytate corn, and whether land was limited for manure application. If certain feed ingredients were reduced (especially amino acids tryptophan, valine, and isoleucine), then there would be a greater confidence that use of these amino acids would be profitable. Continued research is needed to determine the amino acid requirements and ratios for different lean genetic lines, especially in commercial settings, so that greater reduction in excretion and greater implementation of these diet manipulation techniques. In typical corn-soybean meal diets, two-thirds of the phosphorus is bound as phytic acid, making it unavailable to pigs and consequently excreted. By using a phytase enzyme or low-phytate corn and formulating diets on an available phosphorus basis, phosphorus excretion can be reduced 20 to 30%. The use of both low-phytate cereals and phytate enzyme can reduce phosphorus excretion 40 to 50%. Alternatively, enhanced processing of the corn fraction of the diet to remove the germ and hull will remove 90% of the phytic phosphorus and the fiber from the corn and can decrease P excretion 30% and DM excretion 40%. However, this further processing of the corn can lead to increased death loss due to ulcers and needs further refinement before implementation by the industry. Dietary manipulation using the techniques tested in this project is a very effective method to reduce the environmental impact of pork production. As a result, operations producing a majority of the pigs are using some of these techniques on their commercial operations. Given Indiana's current national leadership position in pork production, and the efforts underway statewide to expand the industry amidst environmental opposition in many communities, these research results and their adoption by swine producers are critical to the future success of the Indiana swine industry.

Impact Title Turkey Nutrient Excretion and Volatilization

Aerial and manure excretion for turkeys is largely unknown and needed for environmental impact and regulatory policy purposes. An experiment was conducted to determine the fate of phosphorus (P) and nitrogen (N) for turkeys fed two diets at three ages via mass balance based on nutrient composition and weight of consumed feed, carcass and litter. Mass of P excreted at 12, 15, and 18 week of age was 37, 46, and 40 % more for birds fed an industry (I) diet versus birds fed low phosphorus (LP) diets. The N retained averaged 90.7, 136.7, and 184.2 g/bird while N excreted averaged 377.6, 620.7, and 921.8 g/bird at 12, 15, and 18 week of age, respectively. The calculated N volatilization at 18 weeks was 427 and 405 g/bird for birds fed the I and LP diets, respectively (40 and 37 % of excreted N).

Impact: Values obtained in this trial were compared to the latest turkey excretion model developed by the American Society of Agricultural and Biological Engineers. The ASABE standard over-estimated turkey excretion, nitrogen, and phosphorus by 15 and 9%. This study also is a first to estimate nitrogen volatilization for a complete production phase for turkeys. This is critical importance in Indiana since it is a major turkey producing state.

Biology, Management and Distribution of Glyphosate Resistant Horseweed (Conyza canadensis) and Other Weeds

Production of Roundup Ready™ soybeans and utilization of no-till practices relies on extensive use of the herbicide glyphosate (Roundup™). In 2006 more than 90% of soybean acres in Indiana were planted with Roundup Ready™ varieties and no-till production practices were utilized on approximately 60% of the soybean acres. However, adoption of no-till practices and increased reliance on glyphosate has resulted in a serious concern for long-term use of this valuable weed management tool. Glyphosate resistant horseweed (a.k.a. marestail) was discovered in 2002 at a few sites in southeast Indiana and southwest Ohio. This weed can germinate in the fall, spring or summer and its seed is easily moved by wind. Tillage temporarily eliminates the threat of horseweed, but must be repeated to prevent reinfestation. Widespread return to intensive tillage would negatively impact crop production efficiency and could reverse productivity and environmental gains. A series of studies in numerous fields around the state plus greenhouse studies have documented the distribution, biology and management of glyphosate-resistant horseweed and other weeds.

Impact: Approimately 500 horseweed seed samples (out of over 1300 sites visited) have been collected in Indiana. This sampling for detection of a herbicide-resistant weed is the most extensive ever conducted in the United States. These unique data set will allow us examine the effects of farming practices on the development and spread of herbicide resistance at a landscape level. We have shown that glyphosate resistant horseweed is present in 29 counties in Indiana. Its prevalence is mostly associated with no-till cropping systems and in fields with wheat or soybean as the previous crop. Resistance ratios of 2 to 39 have been found in selected populations. Cross resistance to glyphosate and ALS inhibitors has been found in about 20% of the populations. Two populations have been identified with elevated tolerance to 2,4-D. Field studies on the biology and management of horseweed have shown that it is relatively easy to control simply by using something other than glyphosate for its control. Seedbank studies have shown horseweed seed is not persistent in the soil and that a resistant population can be exhausted within two years. Other studies are being conducted to determine if glyphosate resistant horseweed can serve as a sentinel species for other weeds with enhanced glyphosate tolerance. Common lambsquarter and giant ragweed are under investigation in several fields in Indiana. Indiana growers have been active participants in these field-level resistant weed collection studies.

Identity-Preservation Systems for Value-Added Quality Grains

The localized concentration of fine material in the core grain mass after loading a bin causes the airflow to distribute non-uniformly. As part of this integrated project, the fine material distribution in the grain mass and the air velocity at the center and periphery locations in the bin were quantified for 15 on-farm natural air / low temperature (NA/LT) in-bin drying and conditioning tests. The effect of best management practices (i.e., leveling the grain peak after filling the bin and coring the grain mass) on fine material distribution and/or airflow distribution were quantified. When the grain peak was not leveled, the airflow distribution resulted in a non-uniformity factor of 89% versus 36% after leveling. The coring operation reduced the concentration of fine material at the center of the grain mass by one percentage point and reduced the non-uniformity factor to -28%. The effect of best management practices on the performance of NA/LT in-bin drying systems were further investigated using simulation for four representative locations in the Midwestern Corn Belt (North Platte, Nebraska; Des Moines, Iowa; Indianapolis, Indiana; and Evansville, Indiana). The total overall drying cost savings gained from applying these simple best management practices

ranged from 39% to 49%. The savings were more significant in the northern and western regions (North Platte and Des Moines) than in the southern and eastern regions (Indianapolis and Evansville).

Impact: This project involves simulation analysis and applied research to evaluate less detrimental technologies, such as low temperature and combination drying, and chilled grain aeration and conditioning for a range of cereal grains and oilseeds, for implementation on farms and at commercial facilities. Modeling work primarily focuses on improving the accuracy (using the finite element and finite difference numerical methods) and expanding the adoption of the Purdue Post-Harvest Aeration & Storage Simulation Tools into computer-based commercial grain management systems. Applied research is primarily conducted in the pilot-scale storage structures of the Purdue University Post-Harvest Education & Research Center, and in full-scale systems of collaborating producers, handlers and processors located a several Midwest sites. The refinement and field testing of the self-adapting variable heat fan and heater control system is currently being incorporated into a commercial application. A commercial prototype was tested during the spring of 2006. The equilibrium moisture content controller is expected to be introduced for the 2007 crop drying season.

Corn, Soybean, and Soil Quality Responses to Alternate Cropping Systems

In response to concerns for soil erosion, greenhouse gas emissions, and sustainable crop production, the ability of long-term no-till to improve soil carbon storage and achieve crop yields comparable to those with residue-incorporating, conventional tillage systems are being documented. Long-term tillage trials near West Lafayette (since 1975) and Valparaiso (since 1996) were continued in 2006. These trials confirmed that no-till corn yields are competitive (i.e., within 2 % of those with conventional tillage) as long as corn follows soybeans in rotation. However, no-till corn yields are 14% lower than those with conventional tillage when corn follows corn. Direct carbon dioxide and nitrous oxide gas emission studies from the tillage plots continued in 2006; providing new perspectives on tillage and rotation effects on greenhouse gas release into the atmosphere during the crop growing season. These long-term tillage plots are also providing a unique resource for cooperative studies with plant pathology experts from Purdue University on soil-borne pathogens (e.g., soybean cyst nematode and sudden death syndrome). Zone tillage studies for corn are underway on three major soil types in Indiana. Zone tillage (particularly, fall strip tillage) has the advantages of maintaining essentially the same surface residue cover as no-till, but with the advantage of earlier soil drying in spring, warmer seedbeds, and improved yield consistency relative to conventional tillage systems on the same soil type. Strip tillage studies involving alternate nutrient placements for corn after soybean were continued in 2005 and 2006. The advantages of banded placement of phosphorus (P) and potassium (K) fertilizers for improved crop yields and improved seed quality have been documented on soils where nutrient stratification has occurred. Banding of P and K fertilizers for corn has not generally restricted soybean nutrient uptake or yields when no-till soybeans following corn has received banded fertilizers.

Impact: Information generated from this research has been featured extensively in farm magazines, field days, and agricultural conferences in the United States and other countries (e.g., Australia and Germany) in 2005-2006. Chisel plowing has been proven to be inferior to no-till in the sequestration of soil organic carbon and nitrogen on dark prairie soils. Both no-

till and strip-till systems are helping keep well over 30% residue cover on over 1 million acres of corn each year in Indiana.

Increasing the Consistency and Predictability of Beef Products for Target Markets Through Pre-Harvest Nutrition and Management

Expansion of the ethanol industry is receiving considerable attention across the Midwest. Proper utilization of distiller's by-products as a feed ingredient has the potential to make the beef industry more attractive and competitive in both the domestic and global marketplaces as the price of corn increases in response to growing ethanol demand. The effects on carcass characteristics when distiller's grains are added to beef diets, however, are not fully understood. While distiller's grains are a valuable source of both energy and protein, there is concern in six major areas; 1) variability in distiller's grains quality and consistency across and within ethanol plants , 2) lack of an infrastructure that will allow small to medium-sized operations an opportunity to utilize the by-products, 3) level of sulfur and its affect on animal health, 4) level of polyunsaturated fat and its affect on rumen digestion and beef quality, 5) level of phosphorus and its impact on the environment, and 6) level of nitrogen when distiller's grains are added to diets as a primary energy source and its affect on carcass quality, as well as fertility and embryo survival in beef females. A thorough review of the literature suggests that these six areas could negatively impact producer profitability, animal productivity and end-product quality. Integrated, multidisciplinary research studies are underway to address these important issues associated with feeding distiller's grains.

Impact: Many presentations have been made to producer groups across the state to address these new challenges. There may be new opportunities for the Indian beef sector as a result of the rapid expansion of the ethanol industry in Indiana.