

**Annual Report of Accomplishments
And Results**

**Agricultural Research Programs
Purdue University**

Federal Fiscal Year 2004

William R. Woodson

Submitted by:
William R. Woodson
Dean, College of Agriculture

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A. PLANNED PROGRAMS

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

Overview: A viable crop, livestock, and natural resource system is essential for the success of the Indiana economy. A recent Biocrossroads Report (<http://www.biocrossroads.com/agreport.pdf>) indicated that the wood products, grains, pork/beef, canning, and baking sectors account for 80% of the jobs and wages associated with Indiana's agricultural economy. For 2003 (the most recent year available), cash receipts for Indiana agriculture were \$5.2 billion with 65% from crop sales and 35% from livestock sales. (http://www.nass.usda.gov/in/annbul/0304/2003_04.htm) Indiana ranked ninth nationally in crop receipts in 2003. The 60,000 farms in Indiana represent 2.8% of all U.S. farms. In 2003, Indiana agricultural exports were estimated at \$1.6 billion, 2.9% of total U.S. agricultural exports. Despite being a relatively small state with only 1.6% of total U.S. cropland, in 2003, Indiana ranked second in processing tomatoes, egg-type chicks hatched, and ice cream production; fourth in peppermint, soybean, and total egg production; and fifth in corn, spearmint cantaloupe and watermelon (fresh market), and hog production. 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. In the 2004 crop year Indiana growers set record crop yields, and the livestock sector enjoyed considerable economic success, mostly due to high livestock prices and declines in feed costs later in the year.

Indiana is becoming a leader in the life sciences with increased public and private sector coordination and planning. One of the newest research buildings on the Purdue University campus is dedicated to life science 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. The significance of understanding this blueprint for life is just now being realized with the discovery of the genetic basis for growth and development, and disease. Purdue University scientists are leading the way in genomics, proteomics, metabolomics, nanotechnology, and a state-of-the art hardwood genomics effort. In 2004, 21% of the field corn and 87% 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 development of DNA vaccines for poultry and Arabidopsis gene function discovery. Such discoveries can increase the profitability to 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. Pests, such as the Western corn rootworm, have recently adapted and evolved to counter crop rotation as a biological control strategy, thus resulting in damage in first-year corn. Invasive species regularly enter agricultural system. The soybean aphid, first discovered in Indiana in 2000, became a major pest in northern Indiana in 2003. Purdue University researchers are exploring a variety of approaches to reduce potential pest losses including genetic resistance to pests, insect management on an areawide versus single field basis, biological control, and fewer chemical treatments by following Integrated Pest Management strategies. Applied scientists and extension experts are conducting educational programs with growers on alternatives to combat soybean rust if it appears in Indiana in 2005.

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 to manage stored grain.

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 also 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.

U.S. agriculture is challenged by a very competitive global economy. 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.

Consolidations and mergers in the agribusiness sector have become regular occurrences. 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 is providing Indiana farmers and businesses with opportunities to compete in new markets and obtain greater economic benefits. Purdue University research in this area is closely linked with our various stakeholders and extension educators around the state as together they seek to create new uses for agricultural products, while making more efficient use of natural resources and increasing the competitiveness of producers and agribusiness. One way this is being achieved is through the breeding or genetic modification of grain to make crops more valuable for food, processing, new materials, or energy production. The use of soy-diesel is increasing in Indiana, in part due to the research conducted at Purdue University, and its close collaboration with the Indiana Soybean Board. As a result of this relationship, the Indiana Soybean Board has generated financial support that has resulted in two endowed research chairs at Purdue University—one in soybean genetics and one 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.

Successes

- Pre-and post-harvest nutritional and management strategies can improve the taste and tenderness of beef.
- Research on organic apple production can prevent growers from adopting unprofitable practices.
- Timing and application methods for a bioherbicide (*microsphaeropsis amaranthi*) may help farmers control weeds such as water hemp.

- The dynamic relationship between thrips and *orius insidiosus* (a predator) may help control soybean aphids.
- Genes have been identified that help us better understand fruit maturation, ripening and shelf life.
- Sequencing of selected genes in the Hessian fly, fruit fly and malaria mosquito should lead to better insect control methods.
- Identification of a gene resistant to Roundup in Arabidopsis should help better understand Roundup resistance in marestail, a major weed in corn and soybean production.
- Genes responsible for bone strength in commercial layer hens have been identified.
- Signaling pathways and muscle fiber development in swine should result in improved animal growth efficiency and product quality.
- Development of marker genes for wild type and transgenic medaka fish offer a better understanding of potential environmental risks of unintentional transgene escape with wild species.
- Growing “pharma crops” in caves or under ground mines with special high-intensity discharge lights could help alleviate public concern regarding escape of GM germplasm grown for pharmaceutical purposes.
- Cutting height should be increased for the penultimate harvest of alfalfa in cold climates to enhance vegetable storage protein accumulation and enhance winter survival.
- Alternatives to organophosphate insecticides for codling and oriental fruit moth in apples were found to be effective.
- Nematologists associated with a multi-state research committee developed a standard method for producing inocilin for their experiments.
- Application techniques to reduce fungicide use on golf courses were developed.
- Vitamin K supplement in swine feed can be eliminated and other approaches used to prevent the occurrence of porcine hemorrhagic syndrome.
- Two emerging therapies to manage metabolic disease in dairy cattle were examined.
- A DNA vaccine to control infectious bursal diseases in poultry was tested.
- Micro fluidic devices for rapid detection of pathogens have been developed and tested.
- Novel rheological methods based on ultrasound and acoustic waves have been developed and tested for a variety of cereal products and frozen foods.

Benefits

- Investing in an aerator to incorporate P and K in tall fescue pasture is not economically justified.
- Research and extension efforts on no-till and strip-till systems are helping keep over 30% residue cover on one million acres of corn annually in Indiana.
- Genes responsible for heartwood production in black walnuts have been isolated and should result in a 10-year reduction in the time required to produce trees of commercial value.
- Results of research on chemical and genetic manipulation of pulp wood could reduce chemical use in pulping and increase mill throughput by 60%.
- Three soft red winter wheat varieties with resistance to *Fusarium* head blight, a major wheat disease in the Eastern Corn Belt, were released to the seed industry.
- In soybean cyst nematode infected fields, the Cystx germplasm developed by Purdue University scientists can increase revenue by \$15-90 per acre.
- Inadequate combine monitor calibration during harvest can distort yield information and future crop management decisions.
- RTK auto guidance systems are less profitable than lightbars on DGPS auto guidance systems.
- After a six-year, on-farm, intensive study in three 16-square mile sites in four Midwestern states, only 17% of the farmers preferred an area wide approach to corn rootworm control versus soil insecticides, crop rotation or GM varieties.

- Analysis of a soybean heating oil were found to be cheaper or of equivalent cost for about two-thirds of the time during a recent 4-year period.

State Assessment of Accomplishments:

Research at Purdue University continues to address the needs of various diverse stakeholders along 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, and developing the base for value added products that have the potential benefits for consumers and producers.

Resources:

Approximately \$ 4.04 million of Federal formula funds and \$22.16 million state funds plus 172.6 FTEs have been invested in Goal 1. This is a best estimate and these are not presented as auditable numbers.

1A. Integrated and Sustainable Crop and Livestock Production Systems

Key Theme: Rangeland/Pasture Management (1)

- a. **Description:** In the Tall Fescue Belt in the United States, approximately 30 to 35 million acres of this cool-season perennial grass, is unsuitable for tillage because of topography constraints and fertilizer applications of phosphorus (P) and potassium (K) are neglected. With perennial forage crops it is difficult to incorporate needed nutrients into the soil profile as fertilizers are typically broadcast applied. When these nutrients are applied without incorporation the end result is stratification. Aerators, implements developed to remediate soil physical properties, have not been evaluated for the incorporation of surface-applied fertilizer deeper into the soil profile. This research was conducted in southern Indiana on tall fescue hay and pasture fields. The experimental design was a randomized complete block with a split-block arrangement of treatments with four replications. Main treatments were spring aeration or no spring aeration, with or without P fertilizer, and with or without K fertilizer. In the autumn subsequent to the spring aeration, an additional aeration treatment was applied on half of each block as a split-block. The objectives of the research were to examine whether use of an aerator incorporated phosphorus and potassium to an 8-inch depth, and improved tall fescue yield or forage quality. Use of the aerator in tall fescue hay and pasture fields did not reduce soil P and K stratification. Regardless of aeration or fertilization treatment, greater than 50 percent total soil P was determined to be in the surface 2 inches and greater than 50 percent total soil K was located in the surface 4 inches of the 8-inch soil sampling zone. Aeration had no consistent positive effect on tall fescue dry matter yield and forage quality.
- b. **Impact:** Tall fescue producers should not utilize an aerator for the purpose of incorporating phosphorus and potassium fertilizers as use of the implement did not reduce nutrient stratification or result in improved dry matter yield or forage quality. Investment in the aerator for the purposes of incorporating P and K and improved tall fescue forage yield and quality in a pasture or hayfield is not justified.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Midwest

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

- a. *Description:* Consumers like the taste of beef and beef demand has increased over the past several years following nearly two decades of decline. In part, this can be attributed to increased consumer awareness of the important nutrients (zinc, iron, and protein) contained in beef, popularity of the Atkin's diet, a better understanding of the saturated/unsaturated fat debate, and the unique taste of beef. In consumer sensory evaluations, beef that is perceived to be more tender is typically also considered to be more juicy and flavorful. Tenderness of beef strip loins and rib steaks were evaluated using Warner Bratzler shear force and sensory evaluation. Dry aging of carcasses (14 days) produced rib steaks that were determined to be more tender, juicy, flavorful, and acceptable than rib steaks of the same quality grade purchased at the retail counter. Sensory panel attributes of strip loin steaks did not differ, however, between dry aged or retail steaks. The use of implants to promote growth and improve feed efficiency in feedlot cattle is well established. Quality grade (an indicator of beef tenderness, juiciness, and flavor), however, is often lowered when aggressive implant strategies are used. Results from this study suggest that moderately aggressive implant strategies can be used to enhance live animal performance, feed efficiency and carcass weight, without adversely affecting beef tenderness. Marbling score, used in the determination of quality grade, was reduced, in this study, but eating satisfaction and product acceptability were not affected.
- c. *Impact:* Value-added, niche market opportunities are being created for Indiana beef producers interested in providing consumers with high quality, uniform beef products. Consumer demand for beef is significantly affected by taste, tenderness and consistency. Pre- and post-harvest nutritional and management strategies that can improve the consistency of either beef's taste or tenderness should appeal to consumers, increase demand, and add value to beef products. Results from studies conducted at Purdue University suggest that the use of moderately aggressive implant strategies on weanling calves placed into the feedlot can increase the economically important traits of average daily gain, feed efficiency, and carcass weight, without adversely affecting beef tenderness. Using the time honored process of dry aging of carcasses for 14 days can then be used to increase beef's tenderness, flavor intensity, juiciness, consistency, and overall acceptability, without adversely affecting the microbial assessment. These two management strategies easily fit into certified freezer beef programs where producers market reputation-based beef products directly to consumers.
- c. *Source of Federal Funds:* Hatch, USDA-IFAFS
- d. *Scope of Impact:* United States

Key Theme: Organic Agriculture (1)

- a. *Description:* Applications of neem to young apple trees have proven to be a successful method for avoiding injury from Japanese beetles. It appears that the neem acts as a repellent rather than as a toxicant. In 2003, a single application of neem kept the beetles off the trees for the entire season. Conventional trees averaged 62.2 fruit per tree, totaling 22.3 pounds of fruit per tree, for an average fruit weight of 0.36 pounds per fruit. The organic trees averaged 3.0 fruit per tree, totaling 0.99 pounds of fruit per tree, for an average of 0.33 pounds per fruit. These differences are most likely the result of poor weed control early in the growth of the trees. The location of our organic orchard has proven to be very favorable for avoiding insect control. Three codling moth pheromone traps were maintained during 2003 and 2004, with almost no moths captured in the traps and no codling moth damage observed at harvest.
- b. *Impact:* This study is generating information on the feasibility of growing apples organically in the Midwest. The result may prevent growers from attempting an unprofitable enterprise.

- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Midwest

Key Theme: Organic Agriculture (2)

- a. *Description:* An advisory board of extension personnel and county agents was formed to facilitate on-farm data collection, to help assess the relative advantages and limitations of different vegetable systems and to identify continuing and emerging problems in weed management. The board assisted in the development of a questionnaire and in identifying farmers who might participate in this project, including organic, fresh market and commercial processing tomato growers. The questionnaire was completed in 2003 and 2004 by eight production, nine fresh market and seven organic tomato growers located within 120 miles of Purdue University. Growers were asked to provide information related to overall farm management including farm size, income, cropping systems, and pesticide management.
- b. *Impact:* Preliminary analyses suggest substantial differences among the three groups of growers in farm size, crop diversity and weed management practices. We anticipate that our research will provide tomato growers in the North Central region with the knowledge necessary to evaluate the relationship between weed management systems and weed species diversity and abundance. This knowledge should enable farmers to make more informed decisions regarding the adoption of alternative management systems.
- c. *Source of Federal Funds:* Hatch, NC-IPM
- d. *Scope of Impact:* North Central United States

Key Theme: Plant Production Efficiency (1)

- a. *Description:* We have investigated the interactions between *Microsphaeropsis amaranthi*, a bioherbicide, and the herbicide glyphosate. Interestingly, the interaction is completely different when the bioherbicide and the herbicide are applied to waterhemp plants at different times. When the bioherbicide is applied first, the effect of glyphosate is reduced, and we hypothesize that the presence of fungal infection limits the absorption and translocation of the chemical herbicide. When the chemical herbicide is applied first it predisposes waterhemp to attack by the bioherbicide resulting in increased levels of control of the weed. We hypothesize that this predisposition is a result of the suppression of plant chemical defenses as a result of an inhibition of the shikimic acid pathway - the target pathway of the chemical herbicide. We obtained permits and have tested the efficacy of *M. amaranthi* in the field. We sprayed waterhemp and redroot pigweed seedlings with conidial suspensions of *M. amaranthi* at 6 pm every Thursday from April 22 to August 5, 2004. We found that *M. amaranthi* has the potential to cause severe and damaging symptoms to common waterhemp and redroot pigweed when the nighttime temperature is between 12 to 25 celsius and there is a leaf wetness duration of at least nine hours. Infection severity was limited with less conducive conditions. As a result, of the fourteen weeks the bioherbicide was tested, it was completely successful three times, partially successful four times and failed seven times. Future research will investigate formulations and other methods to alleviate the environmental requirements of the bioherbicide. We have investigated application technology for the deployment of *M. amaranthi*. The bioherbicide was applied as a foliar spray using a range of different hydraulic nozzles. Spray volumes and spore concentrations were kept constant. We found dramatic differences in efficacy from different types of sprays. In particular, efficacy was poor for sprays that generated large droplets (larger than 200 um) and efficacy was very high for sprays that generated small droplets (less than 100 um). Of the nozzles tested, the most effective was a hollow cone nozzle that generated swirling clouds of very fine droplets that penetrated the plant canopy

and resulted in stem lesions as well as leaf lesions on the target. Interestingly, this is a type of nozzle that is normally used for the application of fungicides and insecticides rather than herbicides.

- b. *Impact: Microsphaeropsis amaranthi* shows promise as a bioherbicide candidate. Future research will investigate the mechanism of interactions between the bioherbicide and chemical herbicides, develop improved deployment methods and conduct further field testing. The expected impact is a bioherbicide that that will give Midwestern farmers an additional tool with which to battle troublesome weeds in the genus *Amaranthus*.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Midwest

Key Theme: GIS/GPS (1)

- a. *Description:* Studies have been carried out in spearmint and peppermint to assess the potential of site-specific weed management. Research is emphasizing use of multi-spectral and hyper-spectral aerial photography coupled with ground truthing to determine levels of weed infestation and necessity for management. Results have shown potential of these site-specific techniques to allow precise determination of weed infestation levels, and specific types of weeds in the mint fields. Our research has focused on differentiating weed types and levels of infestation/impact so specific management practices can be used to reduce unnecessary herbicide applications and more precisely manage weeds.
- b. *Impact:* This research is benefiting growers by providing weed management programs that emphasize targeted and reduced use of herbicides in an integrated sustainable manner and is testing new technology that has great potential for allowing site-specific management of pest problems.
- c. *Source of Federal Funds:* Hatch, NC-IPM
- d. *Scope of Impact:* Indiana

Key Impact: Invasive Species (1)

- a. *Description:* In the summer 2004, we used intensive monitoring of experimentally modified field plots to document how the dynamic relationship between thrips and *Orius insidiosus* affects the predators impact on soybean aphid population growth. We also measured the thrips-*O. insidiosus*-soybean aphid dynamic in multiple fields, and are using these data to identify how variation in key spatial and temporal relationships influence the predators ability to mitigate aphid outbreaks. In a related study we protected soybean aphids from natural enemies by caging them. These aphids showed a 4-6 fold increase in density in the week inside cages. In contrast, aphids exposed in the field showed that less than 30% enjoyed positive population growth. The resultant number of aphids in the field was negatively related to the density of *O. insidiosus* in the field. By better understanding key dynamics in this system between the two prey species and their shared generalist predator, we can improve our ability to forecast aphid densities and damage potential. The long-term goal is to develop tools that optimize the use of natural enemies in soybean aphid management and thereby reduce improper use of pesticides in soybean.
- b. *Impact:* Our proposed research will help position IPM specialists to develop a more predictive framework for managing soybean aphid than is currently available. Specifically, knowing how early season predation impacts soybean aphid population trajectories would suggest sampling protocols to determine the distribution and abundance of predators, and alternative prey at the time of invasion.

- c. *Source of Federal Funds:* Hatch, NC-IPM
- d. *Scope of Impact:* Midwest

1B. Genetic Resource Development

Key Theme: Plant Genomics (1)

- a. *Description:* Fruit maturation and ripening are genetically regulated complex processes which involve interplay of plant hormones and growth regulators with numerous biological and environmental factors. Despite intense physiological and biochemical studies for over two decades, the molecular basis of fruit development is not yet understood. To unravel molecular determinants of fruit development including ripening process we have developed a tomato cDNA macroarray containing in excess of 1000 unique fruit expressed cDNAs and used this platform to understand transcriptional circuitries during fruit development including ripening. We identified 364 genes that are differentially expressed during fruit development and ripening. Approximately 24% of these genes are involved in metabolism and protein biosynthesis and degradation, and over 100 genes encode for defense related, cell structure and cell wall related functions, signaling, transcription and transport. Expression profiling indicates that early fruit development and onset of ripening is perceived as a stress phenomenon as many defense and stress related genes are up-regulated at these stages. The mature green stage of the fruit appears to be a transcriptionally quiescent stage where a large number of ESTs show decrease in their transcripts levels. Coordinated increase in expressions of ethylene signaling cascade genes at the onset of ripening, members of glycolytic pathway and chloroplast related genes during ripening and the ubiquitin-protease mediated protein degradation associated genes during the late ripening and senescence phase were observed. Many ESTs with unknown biological functions showed similar developmental regulated expression profiles indicating that they play significant roles in fruit maturation and ripening. Taken together, our results provide a basis for identifying many additional genes that either directly or indirectly play roles in fruit maturation, ripening and postharvest shelf life.
- b. *Impact:* Fruit quality is very significant both from economic and consumer viewpoints. Significant amounts of horticultural produce are wasted due to lack of shelf life. This research suggests *Vis1* will provide a useful gene to enhance quality of fruits in general, and tomato specifically. The *pme* promoters would be useful to target expression of desirable genes products.
- b. *Source of Federal Funds:* Hatch
- c. *Scope of Impact:* Global

Key Theme: Plant Genomics (2)

- a. *Description:* We have compared the 2,085 individual entries in the database containing expressed sequence tags (ESTs) from our black walnut (*Juglans nigra*) transition zone (TZ) cDNA library to both the recently compiled genomic sequence for *Populus trichocarpa* (<http://genome.jgi-psf.org/Poptr1/Poptr1.home.html>) and that of *Arabidopsis thaliana*. Products of genes expressed in the TZ of walnut during late autumn are thought to be responsible for converting sapwood to heartwood. Throughout the 2004 growing season, we have harvested tissues (leaves, branches, roots, and stem cross-sections) from 35-year-old black walnut trees. Upon collection, the samples were immediately frozen in liquid nitrogen (in the field) before being transported to the laboratory, where they are stored at -84

degrees C. We are now evaluating various techniques for extracting intact mRNA from different walnut cell types and tissues (sapwood, heartwood, cambial meristem, transition zone, roots, and leaves).

- b. *Impact:* Black walnut, an extremely valuable fine hardwood, has genetic variation in sapwood production that results in trees that have as few as three and as many as 20 annual rings of sapwood. The commercial value of black walnut is determined by its heartwood production. A decrease in the time it spends producing sapwood can result in shorter harvest cycles. For a veneer tree that is harvested when 60 years old, reducing the period of sapwood production by 10 years would have a significant economic impact. Currently, it is possible to cause sapwood to take on the appearance of heartwood by steaming black walnut lumber. However, this treatment is labor-, equipment- and energy-intensive. There would be considerable savings if this step could be eliminated from the manufacturing process. Moreover, shortening rotations and reducing production costs will make more high-quality heartwood available at a lower price to the end-user. Ultimately, this will allow the U.S. furniture-making industry to be more competitive globally.
- c. *Source of Federal Funds:* McIntire-Stennis
- d. *Scope Impact:* Eastern United States

Key Theme: Plant Genomics (3)

- a. *Description:* The end products of the phenylpropanoid pathway play important roles in agriculture and human health. Examples of these compounds include phytoalexins, UV protectants, cell wall polymers, and substances that are now referred to as "nutraceuticals". Our work over the past twelve months has focused on evaluating the reason for phenylpropanoid gene expression in light-grown *Arabidopsis* roots. We found that roots of etiolated and soil-grown plants contain almost no soluble phenylpropanoids, but exposure to light leads to the accumulation of flavonoids, as well as high levels of coniferin, and syringin, compounds not previously reported to be accumulated in *Arabidopsis*. To elucidate the mechanism by which light induces root secondary metabolism, extracts of mutants defective in light perception and light responses were analyzed for phenylpropanoid content. The results of these assays showed that PHYB and CRY2 are the primary photoreceptors involved in light-dependent phenylpropanoid accumulation, and that the HY5 transcription factor is also required for this response. The presence of phenylpropanoids in etiolated roots of *cop1*, *cop9* and *det1* mutants indicate that the corresponding wild-type genes are required to repress root phenylpropanoid biosynthesis in the absence of light. Another aspect of investigation has focused on the pathway by which sinapic acid is synthesized in plants. The *ref1* mutant of *Arabidopsis* accumulates only 10-30% of the sinapate esters found in wild-type plants. Positional cloning of the REF1 gene revealed that it encodes an aldehyde dehydrogenase required for sinapic acid and sinapate ester biosynthesis. When expressed in *E. coli*, REF1 was found to exhibit both sinapaldehyde and coniferaldehyde dehydrogenase activity, and further phenotypic analysis of *ref1* mutant plants showed that they contain less cell wall-esterified ferulic acid. These findings suggest that both ferulic acid and sinapic acid are derived, at least in part, through oxidation of coniferaldehyde and sinapaldehyde. This route is directly opposite to the traditional representation of phenylpropanoid metabolism in which hydroxycinnamic acids are instead precursors of their corresponding aldehydes. The final aspect of our work on phenylpropanoid metabolism has been devoted to improving our ability to quantify cytochrome P450-dependent monooxygenases (P450s), three of which are involved in the reactions of phenylpropanoid metabolism which we study. P450s are integral membrane proteins typically expressed at low levels both in vivo and by heterologous expression systems, often making quantification of these enzymes challenging. We have developed a method for quantifying recombinant FLAG epitope tagged proteins using fluorescence detection of a chromophore-labeled anti-FLAG monoclonal antibody and well-established immunoblot technology. The utility of this technique was

tested using cinnamate 4-hydroxylase (C4H), one of the best-studied plant P450s.

- b. *Impact:* Directed manipulation of the wood chemistry of trees could have huge impacts on both environmental and economic aspects of the pulp and paper industry. Consequently, a considerable amount of effort has been devoted to the modification of lignin, a cell wall component whose removal is a major part of chemical pulping. Analysis of poplar transformed with a cinnamate 4-hydroxylase (C4H) ferulate 5-hydroxylase (F5H) construct demonstrated significant increases in pulping efficiency from greenhouse grown trees. Compared to wild-type wood, decreases of 23 kappa units and increases of >20 ISO brightness units were observed in tree lines exhibiting high syringyl monomer concentrations. These changes were associated with no significant change in total lignin content in the trees, no observed phenotypic differences and no decrease in pulp yields that were not attributable to the enhanced removal of lignin. Estimates from these results indicate the C4H-F5H transformed trees could increase pulp throughputs at the mill by greater than 60%, while concurrently decreasing chemicals used in the pulping process, and the amount of deleterious pulping by-products released into the environment.
- c. *Source of Federal Funding:* Hatch and NSF
- d. *Scope of Impact:* Global

Key Theme: Biotechnology (1)

- a. *Description:* The physical map of the Hessian fly genome was improved by positioning 96 Hessian fly genomic bacterial artificial chromosomes (BACs) on the polytene chromosomes of the Hessian fly by in situ hybridization. A new BAC library of the Hessian fly genome with approximately 30-fold coverage and average insert lengths of 130 kb was constructed from biotype L Hessian flies in collaboration with the Clemson University Genomics Institute (CUGI). The ends of 40 BAC clones in contig-124 and 10 BAC clones in contig-134 have been sequenced. In addition, one BAC clone, Mde8i18, has been completely sequenced. This has generated over 24,000 bp of DNA sequence in 400 to 600 bp fragments that we have positioned along the contigs. Genes within this sequence have been determined to have orthologous genes in the fruit fly (*Drosophila melanogaster*), and the malaria mosquito (*Anopheles gambiae*). This analysis indicated that micro-synteny exists between all three species.
- b. *Impact:* This is the first genetic map of a gall midge species. It will facilitate comparisons between species and permit the discovery of specific genes that are influential in gall midge-plant interactions. Interfering with these interactions may lead to new methods of insect control.
- c. *Source of Federal Funds:* Hatch, USDA-NRI
- d. *Scope of Impact:* United States

Key Theme: Biotechnology (2)

- a. *Description:* The plant cuticle represents a major barrier to the entry of agrochemicals into plants. We are interested in identifying, isolating and characterizing genes that regulate the properties of the plant cuticle. We have recovered mutant Arabidopsis plants in which the permeability of the cuticle to small molecules (such as herbicides) is increased. Resistance to Roundup in marestail appears to be due to a single dominant mutation that may act in concert with a naturally occurring variant of the enzymatic target of Roundup, EPSP synthase. We have engineered an Arabidopsis gene to encode the variant EPSP synthase found in marestail and demonstrated that it confers a modest resistance to Roundup in Arabidopsis. We are presently screening these Arabidopsis plants for mutations in other genes that enhance this resistance in order to identify the gene that confers resistance in marestail. Cloning of this second gene will help us

elucidate the molecular mechanism of Roundup resistance in mareetail.

- b. *Impact:* Understanding of the mechanism of resistance to Roundup seen in mareetail will lead to better management strategies for these resistant biotypes and will help us preserve Roundup and Roundup Ready technology as a sustainable option for future agricultural use.
- c. *Source of Federal Funds:* Hatch, NSF
- d. *Scope of Impact:* Global

Key Theme: Plant Germplasm (1)

- a. *Description:* Two new wheat cultivars, INW0411 and INW0412, were released; both have resistance to *Fusarium* head blight (FHB) and are early maturing. Seed of these cultivars are expected to be available to producers for seeding in the fall of 2006. Both cultivars have resistance to leaf blotch, glume blotch, leaf rust, powdery mildew and soilborne mosaic virus. We discovered a high level of FHB resistance in a wheat relative, *Lophopyrum ponticum*, and are transferring this resistance into wheat. We identified DNA markers closely linked to two genes conferring low FHB incidence. These markers, together with DNA markers already identified that are linked to other FHB resistance genes, should be useful in future breeding and selection for multiple genes for FHB resistance in wheat. The yellow dwarf resistant cultivars, INW0315 and INW0316, performed well in 2004. Even with negligible incidence of yellow dwarf virus in Indiana; these cultivars performed relatively better in the mid-South areas, where yellow dwarf virus was more significant in 2004. The Hessian fly resistance genes linkage block H3-H6-H9-H15 was determined by DNA marker association to be located on chromosome 1AS and not on 5A as previously reported. The oat line P9741A38 ranked at the top of performance nurseries in Indiana in 2003 and 2004 and has excellent resistance to crown rust and yellow dwarf viruses. It will be recommended for release.
- b. *Impact:* Soft winter wheat cultivars INW0101 and INW0102 performed well in Indiana for producers and acreage of these cultivars is expected to increase. INW0302 performed exceptionally well in 2004, likely due to its closed flowers, which limited *Fusarium* head blight infection, together with excellent resistance to glume blotch, leaf rust, powdery mildew, and soilborne mosaic virus. Two new wheat cultivars, INW0411 and INW0412, were released; both have resistance to *Fusarium* head blight (FHB). Both cultivars also have resistance to leaf blotch, glume blotch, leaf rust, powdery mildew and soilborne mosaic virus. INW0304, released in 2003, and also moderately resistant to FHB and very early maturity is expected to be available to producers for seeding in fall 2005. All three cultivars are expected to make significant impact on reducing production and grain quality losses due to FHB.
- c. *Source of Federal Funding:* Hatch, USDA-ARS
- d. *Scope of Impact:* Eastern Corn Belt

Key Theme: Animal Genomics (1)

- a. *Description:* Layer (White Leghorn hens) and broiler (Cobb-Cobb roosters) lines were crossed to generate an F2 resource population of 508 hens over seven hatches. A total of 26 traits related to bone integrity (body weight, bone mineral density, bone mineral content, area, length and width of the tibia and humerus at 35 and 55 weeks of age; tibial bone breaking force, stress, strain, and modulus of elasticity at 60 weeks) was measured in hens in the resource population. Genotypes of 120 microsatellite markers on 28 autosomal groups were determined using the ABI 3700 DNA analyzer and ABI Prism Genotyper software. Interval mapping was conducted using quantitative trait loci (QTL) Express and additive and

dominance effects of putative QTL were estimated. Twenty-four significant QTLs on chromosomes 4, 10, and 27 were detected, and 57 suggestive QTLs were identified across 18 chromosomes. The QTLs impacting bone traits identified explained from 2 to 22% of the total phenotypic variance. These results are significant because they represent the first genome scan for QTL influencing bone traits in chickens, and they demonstrate that genomic regions contribute to variation in bone strength between commercial chicken populations.

- b. *Impact:* This research has identified genomic regions that contribute to variation in bone strength among chickens. Further investigation of these genomic regions will contribute to the implementation of selection strategies aimed at improving bone integrity in chickens in order to alleviate concerns associated with animal welfare and disposal of spent hens at the end of lay.
- c. *Source of Federal Funds:* Hatch, USDA-NRI
- d. *Scope of Impact:* Global

Key Theme: Animal Production Efficiency (1)

- a. *Description:* To characterize the signal transduction pathways that regulate skeletal muscle growth and differentiation, the role of myofiber type in beta-agonist-induced skeletal muscle hypertrophy was investigated. We fed C57BL/6, myosin heavy chain (MyHC) IIX^{-/-} and IIB^{-/-} mice 20 ppm clenbuterol for 2 weeks. Clenbuterol increased soleus, TA and EDL weights by 30, 48 and 50%, respectively. The clenbuterol-induced increase in cross sectional area was fiber type-dependent (type I, IIA, IIX and IIB increased by 6, 28, 66 and 32%, respectively). Lack of the type IIX and IIB genes had no effect on muscle weight of soleus, but blunted the clenbuterol effect in TA and EDL muscles. Knocking out the MyHC IIX gene blocked the normal beta-agonist-stimulated transition to the IIB phenotype. These findings confirm that beta-agonist induced skeletal muscle hypertrophy is fiber type-dependent and coupled to fiber type transition to the fast-twitch phenotype, and suggest that an orderly, step-wise progression through various MyHC may be necessary for complete transition to the fast phenotype. Red and white semitendinosus muscle from pigs fed ractopamine for 3 weeks was used to study ERK signaling. ERK and Akt/Gsk3 signaling pathways were activated in both slow and fast muscles, but activation of these signaling pathways was greater in fast muscles. Results suggest that a differential participation of ERK and/or Akt/Gsk signaling pathways in beta-adrenergic receptor signaling may account for the distinct responsiveness of slow and fast myofibers to ractopamine. To understand the role of AMPK in myofiber specification, we treated C2C12 myotube cultures with 5-aminoimidazole-4-carboxamide-beta-D-ribofuransoside (AICAR), an AMP analog. After 4 days of AICAR treatment, type IIB MyHC protein increased 2-fold, while type I and total MyHC remained relatively unchanged. The role of MAPK in muscle fiber type specification was studied using porcine satellite cell cultures. Addition of the MEK inhibitor, U0126 increased type I MyHC and decreased fast MyHC content. The increase of type IIB MyHC induced by AICAR was blocked by the addition of a MEK inhibitor suggesting ERK signaling is downstream of AMPK activation and fiber type determination. These data suggest that activation of AMPK can lead to changes in muscle MyHC composition and suggest that AMPK and the ERK-MAPK signaling pathways act synergistically to determine myofiber type specification.
- b. *Impact:* These studies involve characterization of the signal transduction pathways that regulate skeletal muscle growth and differentiation and characterization of muscle proteins involved in muscle function. Findings will result in improved understanding of these processes and are important in developing strategies for improving animal growth efficiency and product quality.
- c. *Source of Federal Funding:* Hatch, USDA-NRI

- d. *Scope of Impact:* United States

Key Theme: Risk Management (1)

- a. *Description:* We have developed a suite of novel genetic markers for the study of salamander biology. These markers include microsatellites, major histocompatibility genes, and mitochondrial genes (D-loop). Collectively, these markers will help us evaluate the influence of an organism's genotype on its chances of survival in nature. In addition, we developed a novel molecular marker for the Japanese medaka and used this marker to evaluate breeding success of wildtype and transgenic males. Our experiments show that large, transgenic males have a clear mating advantage over wildtype males and this mating advantage could--in theory--lead to devastating consequences if the transgenic fish escape to mate with wild brethren.
- b. *Impact:* Our work on medaka has illustrated potential problems associated with genetically-modified organisms (GMOs) that breed with their wild kin. Clearly, agricultural operations that rely on transgenic animals must vigilantly guard against the unintentional gene escape into the wild.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Global

1C. Plant Stress Management

Key Theme: Plant Germplasm (1)

- a. *Description:* Research and development of our soybean germplasm, PUSCN14, continues. The germplasm, marketed under the logo CystX, confers complete and broad-based resistance to soybean cyst nematode (SCN), has no yield drag, and is being incorporated into high yielding soybean varieties. The germplasm is licensed and marketed by ACCESS Plant Technology, which owns the logo and authorizes the marketing of CystX varieties with tags that say CystX Gold or CystX Silver (containing at least 95 or 80% CystX, respectively). Over 90% of the new CystX varieties include Roundup Ready, available in maturities I, II, III, and IV. In further research with PUSCN14, four soybean cyst nematode inbreds selected to reproduce on either Hartwig or PI 437.654 were studied in the greenhouse over a two-year period. Dynamics of these populations were observed monthly on Williams 82, PUSCN14, Hartwig and PI 437.654. The number of new cysts (white and yellow) produced on any of these soybean lines followed an oscillating pattern. Numbers of new cysts increased to a high point, and then suddenly crashed. Sometimes these fluctuations occurred gradually over several generations and appeared to be influenced by ambient temperature and day length. The pattern of changes did not appear to be host related, but was more dramatic on Williams 82. During one 6-month period, the number of new cysts on Williams 82 increased from 60 to 103, peaked at 882, and crashed to 38. The fluctuations observed were of new cysts only.
- b. *Impact:* Soybean Cyst Nematode (SCN) is the number one pest of soybeans in the U.S. Our PUSCN14 germplasm can confer complete and broad based resistance with no yield drag and is being incorporated into elite soybean varieties. At a \$5/bu market price, the CystX germplasm has the potential for yield increases worth \$15 - \$90/A in SCN infested fields.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Midwestern United States

Key Theme: Plant Production Efficiency (1)

- a. *Description:* Hydroponic crop stands growing in controlled environments with "intracanopy" placement of low-power fluorescent lamps allows the stands to be half as productive as those grown with traditional high-intensity overhead lighting, but using only 10% as much electrical energy. The lamps occupy too much space to increase lamp number more. We have subsequently designed an intracanopy lighting array consisting of thin strips containing light-emitting diodes (LEDs). The crop stand grows up among the hanging strips. Each strip contains 20 one-inch-square "light engines" arranged sequentially along the strip. Each engine contains seven parallel rows of printed-circuit LEDs that emit narrow-band, monochromatic light. The strips have been designed so that individual engines can be switched on sequentially from the bottom up, thereby allowing interior, lateral lighting to keep pace with the top of the growing crop and avoids the lighting of empty head space not populated with photosynthetic tissues. These first-generation "lightcicle" arrays are equipped with red and blue LEDs that can be switched on and off, and each color LED can be regulated separately in intensity to achieve any shade of purple desired to control different aspects of plant growth. Cowpea (*Vigna unguiculata*) stands are being grown among the glowing strips and are being evaluated for productivity and electrical power consumption. It is expected that the combination of sequential switching, low power and resulting coolness of the lighting system, specific wavelength emissions, and proximity of emitters to plant tissues will result in substantially reduced expenditure of energy to provide adequate plant-growth lighting in controlled environments. In a separate effort, we have teamed with an entrepreneur who wishes to isolate production of genetically engineered crops underground in former mines to mass-produce gene-expression products that can be purified into pharmaceutical drugs or consumed directly by eating harvested plant parts. A facility is needed to grow crops such as transgenic corn under all-electrical lighting in the mine environment, as well as to cope with the natural coolness of the underground environment, and to prevent foreign pollen from entering and transgenic pollen from escaping the contained, controlled-environment facility. We are growing corn from seed to seed under high-intensity discharge (HID) lamps as the only source of photosynthetic light and are optimizing conditions for future underground production of corn. We have ordered a high-bay growth chamber that will allow field corn to grow to harvest maturity under controlled-environment conditions optimized for future application at the mine location. The crop-growth facility to be constructed at the mine will have characteristics that are hybrid between those of a greenhouse and a growth chamber. Instead of requiring a heat-rejection system to remove excess heat from the HID lamps, the waste heat will be harnessed for warming the cool mine air as it is introduced into the facility to bring in fresh carbon dioxide for the contained crops. The mine crop-growth facility is unique and is presently under development.
- b. *Impact:* This is a revolutionary new kind of electrical plant-growth-lighting system that operates at low electrical power, is cool to the touch, and has extremely long-lived solid-state emitters, averaging from 100,000 to 500,000 hours of operating lifetime, and emits wavelengths that match the absorption maxima of major photosynthetic pigments. Furthermore, the lighting arrays can be distributed within and among the foliar canopy of a crop stand and deliver light effectively to all leaves, even after the canopy "closes" with respect to overhead lighting. The lighting system will save considerable operational cost in lighting plants in controlled environments. Mine interiors are dark, cold, and, if limestone, tend to have elevated carbon dioxide in the mine atmosphere. The cost of mass-producing pharmaceutical drugs by low-throughput mammalian cell cultures in a laboratory is costly enough to justify electrical lighting of crops in the mine. High-intensity discharge lamps give off copious amounts of waste heat in addition to light. We are leveraging the waste heat from HID lamps as a resource for heating transgenic crops within a growth facility in the mine. Fresh mine air is mixed with recirculated waste-heat air to maintain warm temperatures around corn crops while bringing fresh carbon dioxide into the growth area. The high CO₂

content in the mine also is an asset in terms of plant growth. Growing Pharma-crops this way will alleviate public concerns regarding escape of GMO germplasm.

c. *Source of Federal Funding:* Hatch and NASA

d. *Scope of Impact:* United States

Key Theme: Plant Production Efficiency (2)

a. *Description:* The impact of photoperiod and cutting management on regulation of vegetative storage protein (VSP) synthesis in alfalfa taproots was studied to determine the effect of short-day photoperiod during 28, 42 and 56 days on growth, N uptake and N partitioning, particularly vegetable storage protein (VSP) accumulation in taproots of two alfalfa cultivars. Reduction of daylength from 16 hours (long day: LD) to 8 hours (short day: SD) during 28 days reduced total plant growth by decreasing shoot growth. Using ¹⁵N labelling, N uptake and N distribution within the plant was determined. The SD treatment resulted in preferential partitioning of N to taproots in comparison with LD conditions. VSP accumulation occurred after only 28 days for plants grown in SD conditions and increased vsp 57 and vsp 32 mRNA transcript levels. Overall, results indicate that photoperiod modulates taproot N accumulation in alfalfa by enhancing both beta-amylase (vsp 57) and vsp 32 gene expression and accumulation. In a second study we studied the role of stubble C/N reserves or residual leaf area (RLA) on the contribution of taproot C/N reserves to alfalfa shoot re-growth after cutting. The effects of two cutting heights (6 or 15 cm), two RLAs (0 or 100%), and two initial C/N reserve levels (High N or Low N) were followed on forage production, N distribution, and C/N reserve dynamics within stubble and taproot. Forage production was mainly affected by initial taproot C/N reserve levels. However, stubble initial organic reserves (and to a lesser extent the RLA) are also of particular importance during early re-growth. The increase of cutting height led increased stubble C/N supply to re-growing shoots, which partly offset the negative effect on forage production and on taproot C/N reserve depletion.

b. *Impact:* The identification of how vegetative storage protein synthesis is regulated will broaden our understanding of N reserve synthesis and utilization in alfalfa, and root gene expression in general. This information on the functional biology of alfalfa is needed if we are going to use modern molecular approaches for alfalfa improvement. Alfalfa management strategies that increase cutting height during the penultimate harvest in autumn should be considered in cold regions with significant winter stress in order to improve alfalfa winter survival and persistence, as well as spring herbage re-growth.

c. *Source of Federal Funding:* Hatch

c. *Scope of Impact:* United States, especially upper North Central

Key Theme: Plant Production Efficiency (3)

a. *Description:* A goal of the NC-215 was to collect and evaluate data on the persistence in the soil of the soybean cyst nematode (SCN) and other nematode species important to the agriculture of the region. Our contributions began in 1994, when we compared SCN egg counts from post-season soil samples with counts in the soil the following spring at the time of planting. We found, as did other researchers in the region, that early in this study egg counts increased 180 - 300%, especially during the winter of 1994 - 1995. To seek explanations a series of experimental modifications were undertaken during the next several years including the immediate processing of some aliquots of post-harvest samples, followed by spring processing of other aliquots. Also, several different modes of storage were tried (mainly storage at different temperatures). In addition, soil cores from upper level cores were separated from lower-level cores, and percentages of diseased eggs were calculated in each instance. Although the numbers of eggs

increased at some locations in the region and decreased at others, the percentage of diseased eggs did not vary in ways that suggested patterns. Storage temperatures of samples did not affect the numbers of females recovered, except that samples that were frozen during storage did have increased numbers of females when they were processed. We concluded that females/eggs of SCN populations in our region survived best in frozen soils. Our laboratory developed a procedure for obtaining reproducible quantities of viable eggs and juveniles from cysts recovered from soils that has been adopted by the other laboratories in the north central region as the standard method for producing inoculum for experiments.

- b. *Impact:* Nematologists are spread thinly over the North Central Region. A multi-state research committee such as NC-215 is the only viable mechanism for meeting on a regular basis and tackling mutual problems in a way that increases the productivity of each state's laboratory. The adoption of the standardized method for production of inoculum that was developed in our laboratory is an excellent example of the fruits of such cooperative multi-state research.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* North Central United States

Key Theme: Invasive Species (1)

- a. *Description:* Studies were conducted at two locations to test insecticides that could serve as alternatives to organophosphate insecticides on apples for control of codling moth and oriental fruit moth. Insect populations at one location were too low to provide meaningful data. Studies at the Purdue Horticultural Farm in 2004 showed that several combinations of alternative insecticides provided control of codling moths that was statistically similar to that provided by a standard organophosphate insecticide, phosmet. Combinations that included fenprothrin (Danitol), acetamiprid (Assail), thiacloprid (Calypso), and methoxyfenozide (Intrepid) all provided excellent levels of control. Both acetamiprid and thiacloprid also provided good to excellent control of spotted tentiform leafminers. During the emergence of Brood X of the periodical cicada, fenprothrin was found to provide excellent protection. A two year study of the invasive behavior of plum curculio into apple orchards was completed. One of the objectives of the study was to determine the relative number of curculio that walk and fly into the orchard. In 2003, clear windowpane traps coated with Tanglefoot were used to intercept flying curculio. Pyramid traps were used to capture crawling individuals. Very few plum curculio were captured in the windowpane traps. In 2004, Pherocon AM traps were used as a replacement for the windowpane traps, and even fewer curculio were captured. Relatively large numbers of curculio were captured in the pyramid traps. In addition, the movement of curculio throughout the orchard was monitored during the early portion of the season.
- b. *Impact:* Apple growers will be able to choose from several viable alternatives to organophosphate insecticides to control codling moth and oriental fruit moth on apples. In addition, several of the alternative insecticides provided control of pests not controlled by organophosphates, which may mean that growers can reduce the overall number of insecticide applications. The use of these less toxic alternatives will increase safety for applicators and farm workers and reduce negative environmental impacts.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Midwest

Key Theme: Ornamental/Green Agriculture (1)

- a. *Description:* The investigation of the epidemiology of gray leaf spot on perennial ryegrass was continued with a survey of perennial ryegrass golf courses and athletic fields in Indiana. Confirmed outbreaks occurred in Jeffersonville and Bloomington. Disease developed in West Lafayette only after infected turf was transplanted into a stand of perennial ryegrass at the Purdue Turfgrass Research Center. Despite one of the coolest summers in the past two decades, significant damage was attributed to gray leaf spot epidemics. The summer of 2004 was preceded by a relatively mild winter, thereby increasing the opportunity for pathogen survival. These observations support our contention that the disease will increase and spread over a broad range of environmental conditions, and that in the lower Midwest, the survival of the pathogen population is the limiting factor in the development of gray leaf spot epidemics. A new project was initiated to investigate factors that influence fungicide performance on golf course fairways. The study evolved from observations that disease was not adequately managed on numerous golf courses where isolates of *Sclerotinia homoeocarpa* were sensitive to commonly used fungicides. One part of the research addresses the residual activity of protectant and penetrant fungicides used for control of dollar spot on creeping bentgrass fairways. Preliminary results of a bioassay indicate that fourteen days after application, effective deposits were not detectable for any of the fungicides tested. Protectant fungicides appeared to begin to lose residual efficacy after 7 days, and effective levels of penetrant fungicides were diminished after 10 days. It is presumed that regular mowing (three times per week) influences fungicide performance by removing active ingredient from growing turf and influences fungicide performance. The results suggest that timing of fungicide applications with respect to the onset of disease-favorable weather has a significant influence on fungicide performance.
- b. *Impact:* Knowledge regarding pathogen survival, the fungicide sensitivity of pathogen populations, and the residual activity of common fungicides will result in more efficient use of turf chemicals and fewer, less severe disease outbreaks. Specifically, the gray leaf spot investigation will help golf course superintendents who are weighing the advantages and disadvantages associated with an approach based on chemical control versus one involving serious renovation with non-host turf species. Also, using the fungicide sensitivity profiles, superintendents gain an awareness of the dollar spot threat on their own golf courses and often change their management practices accordingly. Finally, an understanding of factors that influence fungicide performance will help golf course superintendents make informed decisions regarding the use of fungicides for disease control. Previously, research demonstrated that on some golf courses, unacceptable levels of control could be attributed to an inherent insensitivity (resistance) in the predominant pathogen population. However, there are many cases where outbreaks are severe, despite the predominance of fungicide-sensitive strains. By using fungicides judiciously and in a timely fashion, turf managers are likely to apply less fungicide while maintaining safe, attractive, high quality playing surfaces.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* North Central United States

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

Key Theme: Animal Health (1)

- a. *Description:* An in vitro assay for vitamin K epoxide reductase (VKOR) activity was developed and validated in our laboratory for swine, bovine, equine, canine, rat, mouse, and human hepatic microsomes. We believe that VKOR activity is inhibited by the agent which causes Porcine Hemorrhagic Syndrome (PHS). We have tested small quantities of extracts from feed and the livers of pigs with bleeding disorders, compared these to known anticoagulants such as Warfarin, and found that they all do inhibit

VKOR. We have also compared VKOR activity in pig liver to that in the livers of other species and found that they are similar.

- b. *Impact:* Information gained from this study will allow the swine industry to prevent the occurrence of porcine hemorrhagic syndrome and eliminate the need to supplement swine feed with vitamin K.
- c. *Source of Federal Funds:* Animal Health
- d. *Scope of Impact:* Nationwide

Key Theme: Animal Health (2)

- a. *Description:* Dual-energy X-ray absorptiometry (DEXA) was used to determine bone mineral densities (BMD) of the left tibia together with the fibula as well as the humerus of live, unanesthetized laying hens. We learned that DEXA was a useful tool for the non-invasive evaluation of skeletal integrity in live hens. This conclusion was based on the positive correlations between live bird and excised bone scans as well as between live scans and more traditional invasive bone measurement tests such as bone breaking force and bone ash weight. Densitometry effectively detected changes in bone integrity of live birds fed varying levels of dietary calcium. Hens consuming 1.8, 3.6, and 5.4% levels of dietary calcium had BMD of 0.147, 0.157, and 0.176 g/sq cm, respectively. Likewise, bone ash weight, breaking force, stress, modulus of elasticity as well as eggshell traits also increased linearly in response to increased calcium level in the diet. We discovered that as BMD decreased in White Leghorns, the incidence of bone breakage increased. The DEXA readings were not dependent on the stage of calcification indicating that scans can be done at any time during the ovulatory cycle. We have monitored BMD in live Leghorn and broiler females during their life cycle. The tibial BMD of White Leghorns and broilers increased as the birds aged from 15 to 65 weeks with the BMD of the broiler tibia increasing at a greater rate than the Leghorn tibia. A precipitous drop in BMD occurred during an induced molt of Leghorns subjected to a 10-day feed withdrawal, but we learned that a non-fasting molting regimen was less detrimental to skeletal integrity. Therefore, poor bone mineralization is most critical during the molting phase of a hen's life cycle with evidence towards recovery in BMD by 67 days post-molt.
- b. *Impact:* Because we have shown that dual energy X-ray absorptiometry may be used in live birds as a diagnostic tool to assess skeletal integrity, a genetic breeding company, Hy-Line International, is considering the purchase of a similar unit to be used specifically for their chicken genetic selection program for the purpose of improving skeletal integrity. The QTL results are significant because they represent the first genome scan for QTL influencing bone traits completed in chickens and demonstrate that genomic regions contribute to variation in bone strength. Our long-term goal is to improve skeletal integrity in egg-type chickens by genetic selection for improved BMD.
- c. *Source of Federal Funds:* Animal Health
- d. *Scope of Impact:* United States

Key Theme: Animal Health (3)

- a. *Description:* Glucose is a limited metabolic commodity in transition dairy cows. The health and productivity of dairy cows is limited by inadequate synthesis of glucose in liver. Increased glucose demand can be met through increased capacity for gluconeogenesis, increased supply of glucose precursors or a combination of both processes. Glucagon, a key hormone in glucose homeostasis, acts to promote gluconeogenesis and total glucose output from liver. We determined the effect of short-term administration of glucagon on expression of gluconeogenic enzymes in lactating dairy cattle. Sixteen

multiparous Holstein cows were injected with glucagon or saline injections 4 times over a 24 hour period. Liver biopsy samples were obtained at the end of the treatment period and used for gene expression analysis. Glucagon treatment increased cytosolic phosphoenolpyruvate carboxykinase (PEPCK-C) mRNA by 40% indicating hormonal control of a key component of the glucose synthetic machinery in liver. Effects of changing the supply of glucose precursors on molecular events related to glucose metabolism were tested in a separate experiment. Propionate, absorbed across the rumen wall, is the major glucose precursor for dairy cows and other ruminants. Monensin, an ionophore, increases the production of propionate by rumen bacteria. When fed near the time of calving, monensin can alleviate the symptoms of glucose insufficiency. Beginning 28 days prior to calving, dairy cows were fed either 0, or 300 mg/d of monensin and liver samples were obtained at two week intervals for six weeks. Analysis for PEPCK mRNA in liver biopsy indicates that enhancing propionate production in the rumen, by feeding monensin, acts to induce hepatic PEPCK-C mRNA expression. An increase in PEPCK is linked to greater glucose synthetic capacity. These data establish a link between a primary glucose precursor in ruminants and a key gene that regulates glucose metabolism.

- b. *Impact:* Data from this project can be applied immediately to nutritional management of dairy cows during the transition to lactation. The experiments indicate that end products of rumen fermentation act to alter expression of genes in liver that control their metabolism. Taken together, these experiments provide information on the mode of action of two emerging therapies for metabolic disease in dairy cattle and identify a common molecular link for both hormonal and substrate induction of glucose synthesis.
- c. *Source of Federal Funds:* Animal Health, USDA-NRI
- d. *Scope of Impact:* United States

Key Theme: Animal Health (4)

- a. *Description:* Our laboratory has demonstrated that chickens can be efficaciously protected by DNA vaccination against infectious bursal disease (IBD) with multiple doses of DNA vaccine carrying the large segment gene of infectious bursal disease virus (IBDV). Co-administration of chicken IL-2 and large segment gene of IBDV plasmids was conducted to determine if enhanced protection of chickens against IBD by DNA-mediated vaccination could be achieved. One-day-old chickens were intramuscularly injected with DNA plasmid carrying large segment gene of IBDV strain VE or chicken IL-2 gene individually or both plasmids once, twice, or three times at weekly intervals. Chickens were orally challenged with IBDV strain VE at 3 weeks old and observed for 10 days. Chickens inoculated with two plasmids in the separate legs two times had 58.8 to 64.7% protection against IBD with significantly higher bursal/body weight ratios and significantly lower bursal lesion scores than those only receiving DNA plasmid carrying large segment gene of IBDV strain VE two times (37.5% protection). The results indicated that plasmid encoding chicken IL-2 gene or large segment of IBDV gene given at separate sites two times enhanced protection of chickens against IBD.
- b. *Impact:* Chicken cytokine gene (such as IL-2 gene) co-administered with large segment gene of IBDV has immunomodulatory effect and offers enhanced protection of chickens against IBDV infection by DNA vaccination that does not require live viruses and avoids reverted virulence. Thus, immunostimulating modulators, including chicken IL-2, has the potential to enhance immunity and protection of chickens against IBD by DNA vaccination for practical application in the field situation.
- c. *Source of Federal Funds:* Animal Health
- d. *Scope of Impact:* United States

1E. Farm Business Management, Economics, and Marketing

Key Theme: Agricultural Competitiveness (1)

- a. *Description:* Food consumed away from home affects daily nutrition. On average, a meal eaten at a commercial establishment is less nutritious than a meal consumed at home; in particular, intake of fat and calories is higher. However, this varies by consumer characteristics. Those with more nutrition knowledge and those more concerned with nutrition are less affected by dining out. Also, a fast food meal is less damaging than is a meal at a table service restaurant, including for children. Nevertheless, most of the negative publicity regarding the role of dining out in the growth of obesity has been aimed at the fast food industry. We examined the data to determine whether this may have affected consumer choice between fast food and table service restaurants. A related goal is to examine household scanner data and measure associations between product purchases, emphasizing foods with salient nutritional features, i.e., especially high or low nutrition. We wish to find out whether there are household types who routinely make their purchases with nutrition in mind and whether there are significant numbers who routinely ignore it. Using cluster analysis, we have completed a study of calcium-enhanced orange juice, and found that consumers with more education are more likely to buy this product, as are buyers of other foods perceived as healthy, e.g., fruits and vegetables. They are less likely to buy items like potato chips.
- b. *Impact:* Consumer 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 fast food industry. This research supports previous studies in showing that dining out lowers nutrition and increases caloric intake, but it also suggests that this may be worse at table service restaurants. Preliminary results suggest consumers who are concerned about nutrition may be less likely to dine out in the first place. This concern appears to be more important than the extent of nutrition knowledge. Poor dining habits when eating out may be more due to a failure of will than to a lack of nutrition information. Perhaps more policy attention should be directed to instilling the critical importance of good nutrition, and not just providing explicit information of exactly how to achieve it.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* United States

Key Theme: Precision Agriculture (1)

- a. *Description:* A field-scale yield monitor calibration project was begun in 2002 at the Davis-Purdue Agricultural Center in East-Central Indiana and the Northeast-Purdue Agricultural Center, expanded to the Pinney-Purdue Agricultural Center in Northwest Indiana in 2003, and expanded further in 2004 to the Southeast-Purdue Agricultural Center. The 2004 studies included two hybrids differing for relative maturity and grain test weight potential. The objective is to document and describe the influences of the frequency or timing of yield monitor calibration on the estimates of grain flow, grain moisture content, and, ultimately, grain yield per unit area during the course of a typical harvest season. The manufacturer of the commercial yield monitor used in the study strongly encourages the entry of multiple calibration "loads" to perform the yield monitor calibration. Preliminary data suggest that the magnitude of yield monitor estimation errors increase over the course of the harvest season if the yield monitor is calibrated only at the beginning of the season. Conversely, mid-season calibration procedures retroactively influence the accuracy of earlier-harvested grain yield estimates during the course of post-harvest processing of the data. The accuracy of grain moisture estimates by the combine moisture sensor also decreases as the harvest season progresses, which interestingly influences the estimates of wet weight grain flow by the monitor. Practical challenges to farmers relative to the yield monitor calibration process include: a)

availability of accurate on-farm weigh scales to verify load weight estimates by the yield monitor, b) availability of accurate portable grain moisture meters to verify grain moisture content estimates by the yield monitor, c) difficulty in representing a broad range of grain flow rates in the multiple calibration loads required for the calibration process, and d) the time required to perform regular calibrations during the typically hectic pace of the harvest season monitor grain yield estimates.

- b. *Impact:* By identifying the effects of irregular or infrequent calibration of yield monitors on the estimation of grain yield and grain moisture content, growers will have a clearer idea of the agronomic and economic consequences of not following a purposeful calibration schedule. The consequences of inadequate yield monitor calibration primarily affect the interpretation of yield maps and subsequent decision-making based on those maps. There are few consequences in the marketplace since growers are paid on the basis of grain weight measured at the point of sale and not on the basis of yield.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Corn Belt

Key Theme: GIS/GPS (1)

- a. *Description:* Automated guidance of farm equipment with global positioning systems (GPS) has been introduced in the Midwest in the last two years. Analysis indicated that differentially corrected GPS (DGPS) auto guidance with about 4 inch accuracy is profitable for a substantial group of Corn Belt farmers. The initial benefit for many growers will come from being able to expand farm size with the same equipment. A \$15,000 investment in DGPS auto guidance is a relatively inexpensive way to expand equipment capacity by several hundred acres. In the longer run as farmers become more comfortable with auto guidance technology they will probably find a variety of spatially sensitive practices that could benefit from greater driving accuracy and repeatability. This study used controlled traffic as an example of a spatially sensitive practice, but in the Corn Belt strip tillage, side dressing nitrogen or mechanical weed control may also be beneficial. This study assumed a corn-soybean rotation, but the benefits of GPS auto-guidance will be even greater in higher value crops. At current equipment prices, real time kinematic (RTK) auto guidance is more profitable than foam and disk marker systems for expanding farm operations and for those with soils subject to compaction, but it is not as profitable as lightbars or DGPS auto guidance.
- b. *Impact:* Profitability of GPS auto-guidance has encouraged its adoption. About 5% of U.S. custom applicators used GPS auto-guidance in the spring of 2004. Initial interest in GPS auto-guidance among farmers is focused on reducing investment per acre by farming more area with the same equipment while reducing skip and overlap in field operations, working longer hours, and gaining greater hiring flexibility.
- c. *Source of Federal Funds:* Hatch
- c. *Scope of Impact:* Corn Belt

Key Theme: GIS/GPS (2)

- a. *Description:* Precision Steering (controlled guidance) is now commercially available, but there are uncertainties about the accuracy or repeatability and the economic benefits which stem from improvements in effective width (reduction of overlap between successive passes), reduced turning time (skip passes), less operator fatigue, more hours per day (controlled steering at night) and agronomic benefits (reduced compaction from controlled traffic, zone tillage, precise placement of chemicals and seed). Studies this year included installation of the hydraulic control modules, AutoSteer system, and

Fieldstar terminal on a Fendt 716 tractor provided by AGCO. This system when equipped with a local base station (Real-Time-Kinematic Global Position System, or RTK GPS) is advertised to be capable of 1 inch precision steering. Field tests included planting 5 acres of corn and drilling 7 acres of soybeans at the Agronomy Center for Research and Extension (ACRE). Operators were successfully able to plant the fields while skipping passes and maintaining the prescribed 1 inch accuracy of overlap. A model 7920 John Deere tractor equipped with AutoTrac, but not RTK, was used at the annual ACRE Field Day to demonstrate controlled steering at an approximately 4 inch level of precision. Repeated trips along the same passes revealed the system capable of positioning the tractor within the prescribed distance. By wirelessly transferring the data from the combine, tractor, or sprayer, the fleet manager will be able to document which activities have been completed and keep statistics on machine and operator performance.

- b. *Impact:* The knowledge gained by these studies will be used to design information systems which will enable producers to continuously improve the efficiency and profitability of their machinery operations.
- c. *Source of Federal Funds:* Hatch and Smith-Lever
- d. *Scope of Impact:* Corn Belt

Key Theme: Agricultural Profitability (1)

- a. *Description:* In 2004, the completion of a six-year USDA-ARS/land-grant university areawide corn rootworm study involved a final assessment of the experience of the participating farmers in four states. Mail and personal surveys were conducted with the farmer participants and local input suppliers in Iowa, Kansas, Illinois, and Indiana. Few farmers (17%) were interested in adopting the areawide approach to control corn rootworms. The surveys indicated several reasons for this lack of interest: 1) perception of large transaction and organizational costs, 2) availability of relatively inexpensive alternatives such as soil insecticides and transgenic Bt varieties, 3) crop rotations remained effective at the Kansas site, 4) areawide did not provide effective rootworm control, and 5) concern about the large costs in the initial years of the areawide approach that required paying for scouting services, aerial application of a semio-chemical bait, and the selective use of a soil insecticide. Moreover, interviews with the associated input suppliers revealed few economic incentives for them to promote among their farmer-customers an areawide approach to corn rootworm control through providing scouting services, aerial application services, or the sale of a semio-chemical bait. While the areawide approach could reduce the use of soil insecticides with corresponding potential environmental and human health benefits, this approach to corn rootworm control, with the possible exception of the Kansas location, was not viewed as economically acceptable.
- b. *Impact:* The areawide approach to corn rootworm control, after a six-year on-farm study in three, 16-square mile sites located in four states (Kansas, Iowa, Illinois, and Indiana), does to appear to be economically viable. Few farmers (17%) in a survey conducted at the end of the USDA-ARS funded study expressed interest in an areawide approach that requires careful scouting and the aerial application of a semio-chemical bait that contains a minimal amount of an insecticide such as carbaryl. About one-half the project participants expressed interest in the adoption of a Bt-based transgenic corn to control rootworms. In those sites where crop rotation is not an effective biological control, the majority of the farmers plan to continue the use of soil insecticides.
- c. *Source of Federal Funds:* USDA-ARS
- d. *Scope of Impact:* Corn Belt

1F. Value-Added

Key Theme: Biobased Products (1)

- a. *Description:* Fundamental research in bio-separations is being carried out for both large-scale and small-scale operations. At the small scale, the development of a protein biochip required fundamental understanding of the behavior of proteins at interfaces, and the application of surface chemistry in order to minimize non-specific adsorption. We have shown that coating the oxide surface of a microchip with hydrophobic, C18 (reversed phase) surface, followed by adsorption of BSA (6 kD) effectively blocks adsorption of microorganisms. The assembly of micron-sized devices from micro-machined silicon usually requires photolithographic techniques with the chemical etching, photo-patterning of elastomers and microfabrication of chips involving multi-step chemical procedures. We have developed a technique that physically combines a silicon wafer, an elastomer (PDMS) and microfibers to form patterns of hydrophobic channels, wells, elbows, or orifices that direct fluid flow into controlled boundary layers. Tweezers are used to place glass microfibers in a defined pattern onto an elastomeric (PDMS) hydrophobic film. The film is then manually pressed onto a hydrophobic silicon wafer causing it to fit around the fibers and adhere to the silicon wafer to form a liquid-tight seal around the fibers. The entire process is finished in 15 minutes and results in microscale features with nanoliter volumes. This "press-fit" microdevice is placed on the stage of an upright epifluorescence microscope (Nikon E600N) with a high-pressure mercury lamp as the light source. De-ionized water, 1 ul, is placed in the sample well and is drawn through the device by pulling a vacuum of 127 mm Hg through the outlet tube by suction from a syringe. Using the microscope (Nikon E600N, 60x/0.70 magnification) in fluorescence mode with a source air slit, FITC filter block, and a photomultiplier tube (Hamamatsu R1527P) at the camera port, *Escherichia coli* cells that express green fluorescent protein (GFP) or mixtures of heat-killed *E. coli* cells incubated and labeled with fluorescein-conjugated antibodies are counted. This approach enables rapid adaptation of the techniques to detection of different pathogens since microfiber surfaces coated with sub-micron beads that target specific pathogens may be rapidly prepared. Also bio-separation methods are being used to remove inhibitors from hydrolysates for production of fuel grade ethanol. The hydrolysates were derived from pretreatment of fiber, and contained inhibitors. The use of a hydrophobic adsorbent XAD4 was successful in removing aldehydes and other inhibitors of microorganisms used to ferment biomass derived sugars to ethanol. The fermentable sugars are not retained by the adsorbent hence, making this a useful separation. The principles for the scale-up of the methodology for this method were also developed.
- b. *Impact:* In the case of bionanotechnology, the control of non-specific adsorption yields practical devices capable of rapidly separating pathogens from a background of non-pathogenic microorganisms. The discovery of fundamental properties of surfaces has enabled rapid construction of a microfluidic device for counting cells. This application further advances the use of micro-devices for rapid detection of pathogens. In the case of an adsorption system for the selective removal of fermentation inhibitors, the successful separation enables ethanol fermentation to be carried out from biomass derived hydrolysates. In the absence of this treatment, inhibitors present at levels as low as 0.1 mg/mL are sufficient to completely inhibit the production of the desired product, i.e., ethanol, by recombinant *E. coli*. The technique developed in our laboratory removes these inhibitors, thus making it possible to readily ferment biomass hydrolysates to ethanol.
- c. *Source of Federal Funds:* Hatch and DOE
- d. *Scope of Impact:* United States

Key Theme: Biofuels (1)

- a. *Description:* Soybean heating oil (SHO) has great potential to become a renewable component in residential heating applications. Degummed soybean oil was the renewable resource analyzed during this project. Research has demonstrated SHO 20, 20% degummed soybean oil and 80% petroleum fuel, to be compatible with unmodified residential furnaces. The kinematic viscosity of SHO 20 was 3.46cSt at 100degrees F which was within the ASTM requirement for petroleum fuel oil. The pour point for SHO 20 was -22degrees F. The net heating value of SHO 20 was 135,490 Btu/gal which was only 1-3% lower than the pure petroleum fuel value of 139,167 Btu/gal on a volume basis. Combustion analyses were performed to determine the NOx and SO2 emissions at optimal furnace settings. Petroleum fuel oil, SHO 20 and SHO 50 were all optimized for each furnace setup using O2, smoke spot and CO emissions. The results showed all fuels produced less than 15ppm SO2 at all settings. These values are comparable to the results presented by Batey which showed SO2 emissions of 15ppm for a 20 % soy methyl ester blend with 80 % LS fuel. The NOx emissions for petroleum fuel oil and SHO 20 ranged from 68ppm to 130ppm for all optimized settings. The results from Batey showed NOx emissions of 90ppm for blends of 20 % soy methyl ester and 80 % fuel oil. A long term storage analysis was performed from June 2002 to September 2003 on four different types of fuel. Fuel oil, SHO 10, SHO 50, and degummed soybean oil were all placed in various containers and locations. After the year and four month storage period, the fuels were visually inspected and heat content tests were performed using a bomb calorimeter. The visual inspection results showed that there was no visual stratification of the blends, but some deposits did form inside the containers. The heat content results showed that all of the blends were within two standard deviations of the initial standard means and therefore there was no significant change in heat content after long term storage. Field tests were completed using SHO 10, SHO 20, and SHO 30 at two different residential homes. The field tests consisted of term tests in March 2003 and one long term test in the winter of 2003-04. The results from the SHO 10 and SHO 30 short term tests showed no major problems. The results from the SHO 20 long term test showed only two major problems with the fuel pumps. The fuel pumps failed due to shaft seal failures which were determined not to be a result of soy oil usage. Emissions from the field tests were comparable to the lab tests for SHO 20 in that the SO2 emissions averaged 13ppm and the NOx emissions had an average of 54ppm.
- b. *Impact:* The potential for near-term use of SHO 20 in heating applications does exist. As foreign sources of petroleum oil become more risky/expensive, SHO 20 could feasibly compete on a cost per MBtu basis. In addition, the federal government is under executive orders to replace petroleum usage with renewable less polluting fuels. A four year historic price analysis from January 1999 to January 2003 comparing petroleum fuel oil to SHO 20 on an energy basis showed SHO 20 had an economic advantage in 32% of the reporting periods. The SHO 20 price was within \$0.10/MBtu for another 35% of the reporting periods. This demonstrated the potential for SHO blends to be competitive with petroleum heating oil.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Northern regions of the United States

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

- a. *Description:* This project focuses on the development of mathematical models to describe biological processes. These models are based on the solution of the equations describing the transport of momentum, heat and matter. The solution of these equations requires the knowledge of rheological and thermophysical properties. Specifically, our group is dealing with the determination of properties that play an important role in cereal and food processing, notably dough handling, flaking of cereals (e.g., production of snacks and baked products), evaporation and thermoprocessing. The specific aims of this

project are (1) to develop novel methods to estimate properties that have a significant role on product processability and final product quality and (2) to develop computer models that can accurately represent the processing of food products. We have developed models to describe flaking and dough handling operations.

- b. *Impact:* Novel rheological methods based on ultrasound and acoustic waves have been developed and tested with a variety of cereal products and frozen foods. In addition, a method based on random oscillation of samples squeezed between two parallel plates (squeezing flow) has been developed and used and tested to determine the properties of corn grits during processing (cooking, drying and tempering). The technique has the potential to test the rheological properties of foods with consistency ranging from water to solid grain kernels. A mathematical model has been developed to predict corn flake operations. The model is being used to optimize flaking operations of important cereal companies. This will help the food industry identify key processing parameters that can affect product quality and process efficiency.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Global

Key Theme: New Uses for Agricultural Products (1)

- a. *Description:* Tests of a prototype light timber building frame constructed of low quality timber using round mortise and tenon joints indicate that such frames are able to resist large roof forces such as those caused by snow loads and wind uplift. Tests also show that these frames can resist substantial horizontal loads, but that cross bracing will be needed in areas of high winds unless shear resistant siding is used. Tests also indicate that a small cross bolt can be used to greatly increase the strength and durability of the critical tie beams used in such structures. Test results also indicate that a 2-inch tenon would be satisfactory in the critical corner post to rafter joints in structures up to 30 feet wide. Results also indicate that boring 2-inch diameter mortises into 3.5 inch square beams reduces the bending strength of the beams by only about 10%. However, cutting a 30 degree bevel on these members significantly reduces their strength. Use of pipe rather than wood cross pins was found to significantly increase the withdrawal strength of the tenons from the mortises. Test results also indicate that when used as part of the frame, fascia beams significantly increase the strength of the frame and reduce ridge deflections. The in-plane semi-rigid rotation coefficient for 2-inch tenons was found to be about 5×10^{-6} radians in-lb. Out-of-plane rotation was found to be about twice as great. Use of the semi-rigid rotation coefficients in the structural analysis of the building frame allowed deflections to be predicted with a maximum error of 15%. This result indicates that the performance of similar structures can be reliably estimated through structural analysis-provided the joints are treated as semi-rigid. Tests indicate that cross pins can reduce the bending moment capacity of round mortise and tenon joints such as those used in school chairs. However, performance tests of school chairs indicate that 0.125-inch cross pins reduce the strength of the round mortise and tenon joints used in their construction by only 20%. Hence, cross pins may be considered as an alternative to adhesives in areas of the world where adhesive costs are excessive.
- b. *Impact:* The use of round mortise and tenon joints in light timber frame construction provides the opportunity for the high speed processing of standardized components that can easily be assembled to form a wide variety of modular frame constructions with a multitude of potential end uses. These frames provide potential outlets for square timbers cut from small diameter tree stems or from rounds cut from small diameter stems and can thus lead to better utilization of underutilized timber resources. These frames also provide the means for constructing frames from local resources in less developed regions of the world and can thus lead to significant improvements in quality of life. In addition, the quick and easy assembly of these frames makes them potentially useful for disaster relief in many parts of the world.

c. *Source of Federal Funds:* McIntire-Stennis

d. *Scope of Impact:* Global

Key Theme: Niche Market (1)

a. *Description:* The goal of this 5-state beef consortium is to strengthen economic opportunities for the Eastern Corn Belt's beef industry by providing added value to the consumer through a responsive production and marketing system. High quality, well-marbled, tender beef is the target product to best utilize cattle, land, and human resources in the region. Over 1,400 producers, 2,000 bulls, and 22,000 head of feeder cattle have been certified through this cooperative effort. Certification of feeder cattle has provided valuable information about the quality of cattle in the region and has had an enormous impact on how producers view marketing in the region. Producers have also gained an understanding of the applications and limitations of electronic identification. The value and importance of unique cattle identification has been gaining producer acceptance, especially for disease traceback and data sharing. Much of the work on this initiative has laid the foundation, and created the infrastructure that will support coordinated beef production systems such as the United Producers, Inc.

b. *Impact:* Land grant universities, state cattlemen's associations, state departments of agriculture, Farm Bureau and a livestock marketing cooperative have come together in five states to work on a common beef sector agenda. The most notable impact has been the building of relationships and cooperation among the 21 partner groups in the system.

c. *Source of Federal Funds:* Hatch and USDA-IFAFS

d. *Source of Impact:* Eastern Corn Belt

Goal 2: SAFE AND SECURE FOOD AND FIBER SYSTEM

Overview: Food safety and food defense related issues continue to present considerable public health and economic risks to the food industry and to consumers. The Centers for Disease Control and Prevention (CDC) estimates that 76 million cases of foodborne illness, 325,000 hospitalizations, 5,500 deaths, and costs of \$7.7-\$23 billion occur each year in the United States. These figures represent inherent contamination of foodborne hazards only. Since September 11, 2001, the presence of intentionally added hazards (bioterrorism) have also become very important. Prevention of foodborne illnesses from both intentional and non-intentional hazards is enhanced through effective research and Extension programs that focus on detection, protection and prevention strategies, response and recovery efforts, and education/outreach programs that emphasizes safe food processing, handling, and packaging. Purdue University engages itself to meet state/national food safety and quality goals by establishing multi-disciplinary teams from several departments and colleges on campus. Good examples of such multi-disciplinary efforts can be found in the Center for Food Safety Engineering effort at Purdue and with the newly developed food biosecurity simulations. Considerable efforts are also placed on integrating research and Extension efforts to complex problems and communicate the efforts to important stakeholders and to the public.

Successes:

- Use of a novel non-thermal intervention, using chlorine dioxide in the gaseous form, to inactivate a wide variety of foodborne pathogens and biodefense threats.
- Developed several different pathogen detection platforms using DNA-based, immuno-assay based, optical sensor based, impedance-based, FTIR-based, and ATP-based for detection of foodborne pathogens including *Listeria monocytogenes*, *E. coli*, *Salmonella*, *Campylobacter*, *Bacillus spp.*, and *Fusarium spp.*

- Development of detection systems and prevention systems for mycotoxin-producing molds.
- Development and study of low cost, rapid testing methods for measuring total PCBs and mercury in fish tissue.
- Development of sample preparation devices that can be used to better separate and concentrate samples for microbial detection.
- Development of an intergraded biosecurity computer simulation to help in decision making-processes to lessen public health impacts and economic impacts in a simulated bioterrorist attack on the food supply.
- Development of systems used to improve quality of corn, tomato, and apple products.
- Established on-farm food safety practices to reduce *Salmonella* contamination in swine.
- Development of food handling training programs that are used to determine research impacts and behavioral changes.
- Development of Integrated Pest Management programs to help teach new research and technologies to important end-users.

Benefits:

- By improving food sample separation and concentration methods, we are now able to deliver better samples for microbial detection systems that are being developed. It is an important step (perhaps the most important step) for improving microbial detection technologies.
- Through our research related to foodborne pathogen detection, we are developing technologies that can be used to detect foodborne pathogens quicker, more reliably, and at a cost that the food industry can afford. Improved detection is an important step forward for reducing foodborne illness and developing fast and effective intervention technologies.
- Novel intervention strategies, such as the use of chlorine dioxide gas, provide a good alternative approach for treating ready-to-eat products (i.e., produce) as well as an intervention for biodefense related threats.
- Research and outreach programs are being combined and integrated in a wide variety of program areas.
- The food biosecurity computer simulation incorporates agricultural and economic research and uses this information to develop better response outreach programs to help benefit industry and regulatory agencies.
- Establishing better quality programs for apples, corn, and tomatoes and developing on-farm food safety programs for swine products incorporate important research findings and delivering them for applied and practical uses on farm through Extension-based outreach programs.
- Integrated Pest Management Programs and Retail Food Safety programs utilize the most recent science and brings it to application via certification programs offered to production, manufacturing, and retail food operations.

Resources:

Approximately \$164,827 of Federal formula funds and \$1.97 million of state funds plus 20 FTEs have been invested in Goal 2. This is a best estimate and these are not presented as auditable numbers.

Key Theme: Food Security (1)

- Description:* Efficacy of ClO₂ gas in reducing pathogens on selected fruit and vegetable models, including strawberries, lettuce, green peppers, mushrooms, cantaloupes, apples and oranges, were studied using a batch and a continuous ClO₂ gas treatment system. Different pathogenic bacteria were selected as targets, including *Escherichia coli* O157:H7, *Listeria monocytogenes*, *Salmonella spp.*, and *Shigella spp.* The pathogens were spot-inoculated on selected produce surfaces. Results show that more than a 5 log reduction can be achieved on these produce surfaces while maintaining acceptable quality except for lettuce leaves where leaf discoloration was noted. ClO₂ gas-treated strawberries and green peppers

showed insignificant changes in surface color, minimal and acceptable residues (<1mg/kg) of oxidative species, and extended shelf-life. The results strongly demonstrate that ClO₂ gas sanitizing treatment is a promising alternative to improve the safety and quality of most fruits and vegetables. An automated continuous pilot scale ClO₂ gas treatment system has primarily been developed and is being tested for decontamination of different produce. This continuous system showed even higher efficacy in reducing pathogens on produce than the batch system when using same ClO₂ gas concentration and treatment time. The continuous treatment system can be used to treat produce followed by immediate packaging, cutting, or juice extraction in processing plants. Besides gas concentration, exposure time, temperature, and relative humidity, surface property of produce is another important factor influencing the efficacy data of ClO₂ gas treatment. Higher efficacy data were obtained for green peppers, apples, oranges, and strawberries compared to cantaloupes, mushrooms, and lettuce.

- b. *Impact:* Consumers are always seeking more convenient food products that are fresh and not thermally processed. In turn, fruit and vegetable consumption has increased (over 2.8 fold in the past decade) due to health benefits and delivery of a fresh product. As a result, numerous outbreaks of foodborne pathogenic infections have been associated with fresh and minimally processed produce, such as green onions (Hepatitis A), lettuce (*E. coli* O157:H7, *Listeria monocytogenes*), sprouts (*E. coli* O157:H7), cantaloupes (*Salmonella* spp.), and tomatoes (*L. monocytogenes*). Improving produce safety has been challenging for regulatory agencies and the produce industry due to low effectiveness (<2 log reduction) of current decontamination treatments, such as washing with chlorinated water and other aqueous sanitizers. Results from this research can improve the safety of fruits and vegetables, and enhance our understanding of the potential benefits of gaseous disinfectants in food industry. Gaseous chlorine dioxide (ClO₂) treatments can be one of the most promising non-thermal sanitation technology with high efficacy (>5 log reduction) for pathogen reduction on produce surfaces. The future of this novel technology will be based on development of usable technology and systems for the food industry and further study to justify the public health and quality benefits.
- c. *Source of Federal Funds:* USDA-Integrated Food Safety
- d. *Scope of Impact:* Multi-State

Key Theme: Food Security (2)

- a. *Description.* Sensitive detection of pathogenic bacteria can require costly equipment and extensively trained personnel. Rapid sensitive detection methodologies need to be developed to help monitor pathogen contamination from field to fork. We have begun to develop a series of bacteriophage (bacterial viruses) based assays to allow rapid testing of sample for pathogens. One strategy is built on the industries current method utilizing ATP and the subsequent production of luminescence utilizing the firefly luciferase. We have modified a bacteriophage and coupled it with bioluminescent reporter bacteria for the detection of a metabolite produced after the phage infection of the pathogenic bacteria. The cells begin to produce light if the pathogen is present. The assay being developed can be utilized with equipment currently utilized by the food industry. The second approach uses a modified phage which after infection of the pathogen causes the production of a compound which can be detected in a pregnancy test format. This assay can be utilized by unskilled personnel and allow greater surveillance for the targeted organism.
- b. *Impact:* Bacteriophage based detection of pathogens in the fully developed proposed assays will create safer food for the consumer and potentially protection from bio-weapons. The potential impact of the research is development of assays which can be utilized by both trained and untrained personnel. The

broad potential of the assays will allow testing in a variety of settings from the field to the producer for pathogenic bacteria. The assay can also be broadened to include bio-weapons such as *Bacillus anthracis*.

- c. *Source of Federal Funding:* USDA-Integrated Food Safety
- d. *Scope of Impact:* Global

Key Theme: Food Security (3)

- a. *Description:* On May 4, 2004, Purdue University's Department of Food Science held the nation's first biosecurity simulation for food companies. Forty representatives of the Department's Industrial Associates (corporate advisory board) along with U.S. Department of Agriculture's Director of Homeland Security and Purdue internal media and faculty participated in the one-day program. The simulation was developed by faculty from Purdue's Krannert School of Management and the Purdue Homeland Security Institute's Synthetic Environment for Analysis and Simulation (SEAS) Laboratory. The simulation was modified by food science graduate students and faculty along with Krannert faculty. The graduate students and computer programmers from SEAS modeled the supply chain from supplier to manufacturer to retailer, developed inputs for ten company-based teams [three bulk ingredient companies, four processors, and three retailers] plus a USDA team, a Food and Drug Administration team, and two media sources. The modeled supply chain included products and their ingredients; geographic production, warehousing and shipping information; quantities of production and sales; economic impacts associated with food product recalls; and public health impacts for each U.S. state. The goals were to provide companies an opportunity to test their security plans on a realistic scenario while feeling the pressures of time, publicity, and finances. Data for the simulation were actual data from public and private sources. The "companies" were placed in separate, soundproof rooms according to their place in the supply chain and were provided data from the computer simulation model and from electronic reports from "government" teams and the "media". Participants then made action decisions based on this information and learned the impact of decision making in the following round.
- b. *Impact:* Throughout the simulation, availability of accurate and timely information was vital. The ability of the food companies to communicate with their suppliers, distributors, the media, and government agencies was essential. Teams were provided with an instant-messaging program to communicate publicly or privately with other teams. Most teams made decisions based on information they received from multiple inputs: government releases, media releases, and communications between each other. Good communication enhanced the trace-back of contaminated products and ingredients. Participants were unanimous in their opinion that role playing and simulations are vital to increasing industry awareness and readiness for a bioterrorism attack. What they learned is being applied to various areas in their companies. They not only reviewed their bioterrorism policies but also updated policies regarding human resources, record keeping, production and operations security, and handling during distribution and warehousing. The overall impact is that participants were able to assess and improve their decision making capabilities to improve public health and economic impact.
- c. *Source of Federal Funding:* Hatch
- d. *Scope of Impact:* United States

Key Theme: Foodborne Pathogen Protection (1)

- a. *Description:* The Center for Food Safety Engineering, or CFSE, was established to develop better methods for hazard detection and better ways to control hazards in our food system. We accomplish our

goals by building research teams through collaborative efforts of five different schools including agriculture, consumer and family sciences, engineering, science, and veterinary sciences. We have faculty teams working on methods to detect pathogenic bacteria, molds and seafood toxins, and teams working on bioluminescence techniques that use infrared sensors. Our combined efforts this year led to 30 refereed journal publications and 41 presentations at national/international meetings. Some of the ongoing CFSE projects include:

- Engineering of biosystems for the detection of *Listeria monocytogenes* in foods
 - Biosensor-based approaches for rapid and sensitive detection of *Listeria monocytogenes* from food
 - Detection of specific foodborne pathogens using a two component bacteriophage/bioluminescent reporter system in conjunction with a hand held luminometer
 - Detection of *Fusarium* species in grains and foods by ELISA and PCR
 - Light scattering sensory method for rapid assessment of foodborne bacterial contaminants
 - Rapid detection of total PCBs and toxicity equivalence quotient (TEQ) in fish tissue from Indiana waters and use of a novel device to predict contaminant load in fish
 - Bioamplification using phage display for the detection of *Salmonella* spp. and its evaluation as a technology platform for the simultaneous detection of multiple pathogens in the same sample.
- b. *Impact:* The development of bacterial pathogen detection methods that are more accurate and more rapid, will allow food processors and food regulatory agencies to identify potential problems more quickly. This technology could also be easily applied for detecting potential biosecurity threats, which would help in response and recovery efforts.
- c. *Source of Federal Funding:* USDA-ARS
- d. *Scope of Impact:* United States

Key Theme: Foodborne Pathogen Protection (2)

- a. *Description:* Improving sensitivity and specificity of biosensor tools has continued to be a major focus. A Fiber-Optic sensor has been developed for *Listeria monocytogenes*. This sensor is sensitive and can detect ~1000 cells/ml in a pure culture setup. Sensitivity diminishes when the cells are stressed or present with natural microflora in food. A buffered selective sample enrichment step helps resuscitation of stressed cells and eliminates interference with other microflora. Food containing an initial load of 10-1000 cells/g could be detected in less than 24 h from the point of food sampling. A two-step detection system specific for pathogenic *L. monocytogenes* has also been developed. In step one, *Listeria* cells from enriched ready-to-eat food samples are captured on antibody-coated immunobeads and tested for their ability to kill mammalian cells. This assay is sensitive and extremely specific for cytopathogenic *L. monocytogenes* and results could be obtained in less than 28 hours starting with the food sample. A laser light scattering system has also been developed to distinguish bacterial colonies grown on solid agar plates. This system is able to differentiate closely related bacterial species in minutes. Further testing with contaminated food products is in progress.
- b. *Impact:* The detection tools developed here are sensitive and specific and will enable us to detect only the pathogenic *Listeria monocytogenes* in 24 hours from ready-to-eat food products where this organism is a major concern. Early detection would reduce warehouse holding time for products, and prevent potential foodborne *Listeria monocytogenes* related outbreaks and mortality.
- c. *Source of Federal Funding:* USDA-ARS

c. *Scope of Impact: Multi-State*

Key Theme: Foodborne Pathogen Protection (3)

- a. *Description:* A procedure for capturing antibodies produced against two molds, *Fusarium graminearum* and *Fusarium verticillioides*, in both peptone and cornmeal was developed to use as an immunocapture before doing quantitative real-time polymerase chain reaction (qPCR). The use of the 96-well microtiter plates was the best method to capture the antibodies of the *Fusarium* species; however, there was nonspecific binding. To overcome this binding, blocking agents (bovine serum albumin, beta-casein, nonfat dry milk and Triton-X) were evaluated. None of these agents gave significantly different results from the controls without blocking agents. In order to access the DNA before qPCR, sonication for 45 second for *F. verticillioides* and 120 seconds for *F. graminearum* were used. The qPCR targeted the amplification of two genes involved in mycotoxin production, the Tri6 gene for *F. graminearum* and the Fum1 gene for *F. verticillioides*, which were confirmed on agarose gel electrophoresis. The concentration of *F. verticillioides* affected its detection by qPCR but that of *F. graminearum* did not. Detection of *F. graminearum* was 100 CFU/ml and 100,000 CFU/ml for the buffer and cornmeal, respectively; however, for *F. verticillioides*, it was 100,000 CFU/ml and 10,000,000 CFU/ml for the buffer and cornmeal, respectively. The immunocapture method did not increase the sensitivity of detection of *F. graminearum* and *F. verticillioides* when compared to the PCR results without capture. The q-PCR did not detect other mold when samples containing species of *Byssoschlamys*, *Penicillium*, *Trichoderma*, and *Ulocladium* were included in the assay. Research is continuing on the improvement for the immunocapture step to improve the sensitivity.
- b. *Impact:* Rapid methods are needed to detect molds and pathogenic bacteria in foods. This project will develop rapid methods to detect molds and pathogenic bacteria in foods and develop predictive microbiological models for bacterial pathogens in foods to control their growth or death during and after processing. There is a need to develop rapid methods to detect molds in grains and foods before they can produce mycotoxins that pose a health hazard when used in human food. This research on the immunocapture of *Fusarium* molds shows that the mycelia and spores can be linked to antibodies and then these mycelia and spores can be used in the polymerase chain reaction assay (PCR). The method has to be further refined because once these mycelia or spores are captured, the DNA needs to be released. Methods to do this are still being evaluated. Once this hurdle is overcome, then this method has potential for a rapid method for mold detection.
- c. *Source of Federal Funding:* USDA-ARS
- d. *Scope of Impact: Multi-State*

Key Theme: Foodborne Pathogen Protection (4)

- a. *Description:* Fumonisin are a group of mycotoxins produced by *Fusarium verticillioides* that contaminate corn and cause leukoencephalomalacia in equine, pulmonary edema in swine, and promote cancer in mice. A candidate regulatory gene, ZFR1, was identified in a cDNA library enriched for transcripts expressed by *F. verticillioides* during fumonisin B1 (FB1) biosynthesis. ZFR1 deletion mutants exhibited normal growth and development on maize kernels, but fumonisin production was reduced to less than 10% of that of the wild-type strain. ZFR1 encodes a putative protein of 705 amino acids with sequence similarity to the Zn(II)₂Cys₆ binuclear cluster family that are regulators of both primary and secondary metabolism in fungi. Expression of ZFR1 in colonized germ and de-germed corn kernel tissues correlated with FB1 levels. Overexpression of ZFR1 in *zfr1* mutants restored FB1

production to wild-type levels. The results of this study indicate that ZFR1 is a positive regulator of FB1 biosynthesis in *F. verticillioides*.

- b. *Impact:* The research contributes to our knowledge on genetic factors involved in the biosynthesis of fumonisin. This knowledge will assist in developing methods to prevent mycotoxin contamination in food. This meets important food safety priorities set by FDA and USDA.
- c. *Source of Federal Funding:* USDA-NRI
- d. *Scope of Impact:* United States

Key Theme: Foodborne Pathogen Protection (5)

- a. *Description:* The risk from selected xenobiotics which have been shown to cause developmental delays in children is estimated using Toxicity EQuivalents (TEQ). Calculation of TEQ requires precise measurement of 12 polychlorinated biphenyls (PCBs), 6 polychlorinated dibenzo-p-dioxins (dioxins) and 10 polychlorinated dibenzofurans (furans) is expensive and slow. Thus, measurement of these compounds in fish tissue by classical methods is impractical for analysis of recreationally-caught or commercial fish. For this study, predictive modeling was used to determine which specific chemicals can be used to predict TEQ in fish tissue. Using data from the EPA National Fish Tissue Study (2003), the strongest predictive model ($p < .0001$, $R^2 = 0.97$) included 5 compounds (i.e., 2 PCBs, 2 dioxins, 1 furan); however, the lower limit of detection for measuring these compounds would need to be 0.1 ppt. An alternative model ($p < .0001$, $R^2 = 0.68$), which included 3 PCB congeners, requires a higher lower limit of detection of 1000 ppt. This regression model can be the impetus for the development of a rapid assay for measuring these three compounds and predict TEQ. A rapid assay will improve fish consumption advisories which are created to protect sensitive populations from exposure to environmental pollutants.
- b. *Impact:* Predicting Toxicity EQuivalents (TEQ) in fish tissue by measurement of selected PCB congeners that are present at higher concentrations will facilitate development of a rapid, low cost assay. This assay is needed for the development of fish consumption advisories for recreationally-caught and commercial fish. Fish consumption advisories are intended to protect sensitive populations from exposure to high levels of environmental pollutants.
- c. *Source of Federal Funding:* USDA-ARS
- d. *Scope of Impact:* National

Key Theme: Food Pathogen Protection (6)

- a. *Description:* The engineering of biosystems for detection of *Listeria monocytogenes* in foods has resulted in a system and protocols for detecting a food pathogen from meat. A protocol was developed that follows a sequence of stomaching/homogenization of hot dog, prefiltration, membrane based concentration, recovery of living microbes in a 50 to 100 microliter sample volume, presentation to a biochip or fiber optic detection system, and rapid detection of 10 to 50 viable cells, all in a time period of less than 4 hours. This interdisciplinary team project involves co-investigators from Agricultural and Biological Engineering, Electrical and Computer Engineering, Food Science and Biomedical Engineering to develop a first-of-a-kind approach based on the utilization of a protein biochip for detection of food pathogens from food samples. Prior work in the literature has addressed detection techniques based on clean samples in which bacteria are added to buffers. The rapid processing of biologically complex samples, and fractionation of lipid, fat, protein, colloidal, and particulate matter from microorganisms to

give samples in a form suitable for interrogation by microfluidic devices will result in automated approaches for in-plant pathogen detection by food processors.

- b. *Impact:* Technology for rapid detection of pathogens in foods will impact the consumer by providing safer and high quality foods, while adding value to branded processed foods through enhanced safety using biochip detection systems.
- c. *Source of Federal Funding:* USDA-ARS
- d. *Scope of Impact:* Global

Key Theme: Foodborne Pathogen Protection (7)

- a. *Description:* The presence of *Salmonella* is ubiquitous in livestock and livestock environments. This constant threat to food safety must be addressed. When swine are shipped to slaughter a high percentage of them start to shed *Salmonella*; this reaction is thought to be associated with the stress of transportation and mixing inherent in the process. As few as 4% may be positive for *Salmonella* on the farm, but that percentage can increase up to 40% at the slaughter house. Our lab is investigating the role of stress hormones and their interactions with *Salmonella* in the living pig. Thus far our research shows that *Salmonella* can monitor their host's physiology and respond to the stress hormones it releases. This ability may allow *Salmonella* to take advantage of the low immune function typically found in animals under stress.
- b. *Impact:* We discovered that *Salmonella* can have an enhanced ability to colonize the gastrointestinal tract of swine after exposure to the stress hormone norepinephrine. This discovery is important because it provides a mechanism to explain the fact that we find a low rate of animals testing positive at the farm and the high rate of positive swine at the slaughter plant. These data indicate that bacteria are able to monitor their host and take advantage of the host when it is most susceptible to infection. A complete understanding of this phenomenon will allow the development of strategies to decrease the amount of *Salmonella* found on the carcasses at slaughter.
- c. *Source of Federal Funding:* Hatch
- d. *Scope of Impact:* Multi-State

Key Theme: Food Quality (1)

- a. *Description:* Rapid evaluation of the quality of agricultural products can be used to reduce losses and improve the management of resources. This project is addressing three quality issues. One of the major causes of deterioration of shelled corn is the growth of fungi. Managers of stored grain facilities rely on experience and the reported moisture content when assessing risk of deterioration. A test that could quantify the likelihood of deterioration during continued storage would allow grain to be marketed before it deteriorates. This would reduce losses and improve the overall quality of the corn crop, thereby improving competitiveness in international markets. Internal browning is one of the more common internal defects of apples. Producers experience significant losses when unacceptable levels of this defect prevent the sale of their apples on the fresh market. Non-destructive on-line sorting for this defect would allow defective fruit to be removed. Elimination of internal defects would improve customer satisfaction and increase competitiveness in international markets. The ideal canning tomato is firm with relatively high solids content. There are significant variations in the processing yield of tomatoes that arrive at processing plants. Variations in processing yield among lots of tomatoes are related to differences in

firmness and maturity. Therefore, if tomato lots with superior firmness characteristics could be identified and used for canning, processing efficiency would be increased and losses would be reduced.

- b. *Impact:* A test kit developed by Woods End Research is being adapted for measurement of storability (resistance to invasion by storage fungi) of shelled corn. The test can be completed in two to three days and provides a reasonably accurate assessment of storability. Over 50 samples of shelled corn with varying storage histories and levels of storability have been evaluated using the test kit and additional samples are being tested. A series of relatively rapid tests, requiring less than 15 minutes to complete, are also being evaluated. The goal is to identify a group of tests that could be used for screening samples for storability. Samples identified as having a low storability could then be evaluated more thoroughly using the test kit. Tests were conducted on apples using a low field magnetic resonance sensor. A conveyor system was built to move apples through the sensor at speeds up to 10 inches per second. The best differentiation between healthy and defective apples was achieved when the apples were not moving. However, at a conveyor speed of 2 inches per minute, classification errors of 12% or less were attained. In general, the error increased as the conveyor speed increased. It may be possible to reduce the classification error by modifying the design of the sensing system. Processing tomatoes at various stages of maturity (ranging in color from light pink to dark red) were tested using a low-field magnetic resonance sensor. Compression tests were used to determine the firmness of the tomatoes. The MR signal changed as the tomatoes ripened. The tomatoes that were fully ripe, but not over-ripe had the signal with the longest duration, while the signal duration decreased for both under mature and over mature tomatoes. The results suggest that it would be possible to use MR in combination with color sorting to rapidly assess tomato firmness.
- c. *Source of Federal Funding:* Hatch
- d. *Scope of Impact:* Multi-State

Key Theme: Food Handling (1)

- a. *Description:* The Purdue Pest Management Program coordinates a series of all day winter meetings, Crop Management Workshops, held at five locations throughout Indiana. Extension Specialists representing the Department of Botany and Plant Pathology and the Department of Entomology from Purdue University and the Office of the Indiana State Chemist presented in-depth information on pest management, pesticide regulations, pesticide safety, pesticide application equipment and calibration, and more. The goals of the Crop Management Workshops are to educate Pest Managers on economical and environmental pest (identification, biology, damage, sampling, and thresholds) and pesticide (chemistry, application, regulation, calibration, safety) management.
- b. *Impact:* The Crop Management Workshops effectively reach a targeted audience of agribusiness personnel, "pest managers," that make significant pesticide input decisions on Indiana's farms. Nearly 100% of the Pest Managers participating in a series of all day winter meetings, Crop Management Workshops, coordinated by the Purdue Pest Management Program, indicated by written evaluation that their pesticide decision making abilities were improved. The goals of the Crop Management Workshops are to educate Pest Managers on economical and environmental pest (identification, biology, damage, sampling, and thresholds) and pesticide (chemistry, application, regulation, calibration, safety) management. In 2004, 874 agribusiness personnel attended the Crop Management Workshops. Some of the practices and information discussed included the proper identification of pests and their damage to eliminate needless chemical treatments, using the proper timing and most efficacious products and rates when pesticides are justified, pest trends and anticipated problems for the upcoming season, indications of herbicide resistance with some weed species, and proper use and storage of pesticides. Participants highly

rated the educational value of the meetings as the following evaluation values indicate: 96% of the participants indicated that the Crop Management Workshop improved their pest management decision making ability and 94% indicated that the Crop Management Workshop was worth their time and expense to attend. In multiplying our efforts, nearly half of the participants indicated that they would share the educational materials with colleagues and/or customers.

c. *Source of Federal Funding:* Hatch, Smith-Lever

d. *Scope of Impact:* Indiana

Key Theme: Food Handling (2)

a. *Description:* Foodborne illness continues to be an important concern for consumers nationwide. 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 manager from each retail food establishment be certified in retail food safety and pass a nationally recognized exam. Our focus is to prepare retail food managers for this requirement and teach sound food handling procedures. Three programs are offered in Indiana to address these needs. The Essentials of Food Safety and Sanitation and SuperSafeMark programs were each developed as nationally recognized curriculums and certification program for retail food handlers. The Essentials of Food Safety and Sanitation program is intended mainly for supermarkets and foodservice, and the SuperSafeMark program has been customized for supermarket and convenience store operations. Each program is designed as an 8-hour or 16-hour program for retail food managers and is linked with a retail food certification exam developed with the National Registry of Food Safety Professionals. The targeted audience includes retail food managers and retail food workers. The program is also offered to corporate trainers and academic trainers that serve the retail food industry. We also offer the National Restaurant's ServSafe program that is targeted for restaurants.

b. *Impact.* Within Indiana, the program is offered through the Retail Food Grocers Association, the Indiana Restaurant and Hospitality Association, and Purdue University. The Food Marketing Institute has endorsed SuperSafeMark as the food safety training program for the supermarket industry. The three leading U.S. supermarket chains (Kroger, Albertson's and Safeway), have adopted the program to train and certify their employees. Indiana's largest supermarket chain, Marsh Supermarkets has also adopted this program. Within Indiana, over 3,500 people are certified each year using one of these three programs. These figures are expected to rise significantly after January 2005 when the mandatory certification rule comes into effect. Nationally, the Essentials of Food Safety and Sanitation program ranks as the second most popular retail food safety program and the SuperSafeMark program is the number 1 ranked retail food safety program for supermarkets. This retail food safety curriculum provides an important training need for retail food managers. The training should reduce the risk and likelihood of foodborne illness and improve food-handling practices in retail food establishments.

c. *Source of Federal Funding:* USDA

d. *Scope of Impact:* Multi-state

GOAL 3. A HEALTHY, WELL-NOURISHED POPULATION

Overview: Diet and nutritional concerns are becoming 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.

Calcium and Vitamin D: These two key nutrients to human health are the focus of diverse research at Purdue University. The metabolism of calcium in adolescent boys is quite different than in adolescent girls. Metabolic studies conducted at Purdue University have shown that calcium retention in boys is higher from a given food than it is in girls. Boys are more efficient in using dietary calcium than girls. Implications of this increased calcium retention efficiency in boys, is seen in the size and density of male bone as compared to female bone. These results are being used to revise national dietary requirements. Research also has suggested that there may be differences in calcium absorption among people with diverse ethnic backgrounds or genetic diversity.

Vitamin D, also a factor in adequate calcium absorption, has many other roles in the human body. Normal cells have very tight regulatory mechanisms for growth control and programmed cell death. Cancer is a state where cell growth and programmed death has been changed dramatically from normal. Studies have shown that the active form of Vitamin D (1, 25(OH)₂D) inhibits cell death in normal cells, but not in cancer transformed cells. Understanding the mechanisms of how Vitamin D regulates cell growth and death could ultimately lead to dietary recommendations to reduce the risk of cancer.

Carbohydrates in health: Carbohydrate research continues to be a strength at Purdue University. Studies conducted on methods to moderate starch digestion rate in processed food have resulted in two potentially useful findings. This first is a new process of controlled starch digestion to produce slowly digested starches with food rheological properties. Secondly, the mechanism for the slow starch digestion property seems to be a protein starch interaction which can be created in other cereal flours. These slowly digested starches produce low glycemic responses and may have implications to diabetes, pre-diabetic condition, and possibly obesity.

Functional foods for health: Research conducted in the rat model shows that non-nutrient flavonoids, rich in fruits and vegetables, may exert their protective antioxidant action through increasing the body's own endogenous antioxidant defense system.

Horticulture researchers understand the importance of the nutritional value of fruits and vegetables. Tomato fruits containing several fold higher levels of lycopene have been produced at Purdue University. The bioengineered tomatoes exhibited a three fold increase in lycopene, showed juice quality indicators 50% higher than non-transgenic tomatoes, and were able to stay on the vine significantly longer than parental non-engineered fruits.

Diets higher in fiber in foods have been linked epidemiologically with lower incidence of some chronic diseases, most notably colon cancer. Purdue researchers are investigating the impact of psyllium to modify hepatic gene expression. Hepatic enzymes that regulate the production of cholesterol are targeted for investigation.

Health and aging: Selected brain receptors are putative targets for PP5 regulation in non-neuronal cells and are critical in nervous system development, stress responses and aging. Purdue University scientists are investigating whether PP5 and glucocorticoid receptors are co-localized at the cellular level within these brain regions. PP5 has been shown to be an important tau phosphatase in brain. Since tau phosphorylation is thought to be important in the neurodegenerative processes underlying Alzheimers disease, Purdue University research suggests that PP5 activity in neurons could help prevent the degenerative processes that lead to this debilitating disease associated with aging.

Successes

- Regulatory enzymes have been identified that may be drug targets for nervous, cardiovascular, or endocrine disorders.
- Inulin may serve as a fat replacer to reduce calories in diets.
- Low glycemic index foods show promise in addressing diabetes, cardiovascular disease, and obesity.
- CLA and other polyunsaturated fatty acids in our diets have an impact on cholesterol metabolism and atherosclerosis.
- A study found that to reduce obesity, consumers need both nutrition information and motivational encouragement to develop good eating habits.

Benefits

- Monitoring and measuring about 750 adolescent girls in both intervention and control groups over an 18 month period has helped determine the ability of a multi-media science curriculum to influence food selection behavior, physical activity, and bone growth.
- Mouse models found that females are more responsive to calcium absorption when regulated by vitamin D intake

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 overweight issues. Citizens are provided information regarding potential health impacts of their food choices through Extension education programs and websites.

Resources:

Approximately \$261,754 Federal formula funds and \$1.83 million of state funds plus 20 FTEs have been invested in Goal 3. This is a best estimate and these are not presented as auditable numbers.

Key Theme: Human Health (1)

- a. *Description:* We have generated mutant alleles of associated proteins and have confirmed that they negatively influence histone methylation. We are currently defining how these proteins associate with Set1, the role of these proteins in regulation of Set1s methyltransferase activity, and how these proteins may impact gene expression. We are particularly interested in Set1 and its associated proteins since many of their human homologues have been found to be mutated, amplified or chromosomally translocated in cancer patients. This suggests that they play an important regulatory role in the cell.
- b. *Impact:* The study of the basic function of histone methyltransferase in yeast will help us understand the role of their human counterparts which when mutated can lead to human disease such as cancer.
- c. *Source of Federal funding:* Hatch and NIH
- d. *Scope of Impact:* Global

Key theme: Human Health (2)

- a. *Description:* We are using molecular biology and biochemistry to determine the role of PP5 in hormone and neurotransmitter signal transduction. We purified a lipid-stimulated protein Ser/Thr phosphatase, PP5, from bovine brain. PP5 contains a catalytic domain similar to those of PP1 and PP2A, and an N-terminal TPR (Tetratricopeptide Repeat) domain which typically mediates protein-protein interactions. We found that the TPR domain acts with the C-terminal region to inhibit PP5 and the binding of unsaturated fatty acids to the TPR domain or C-terminal truncation of 10-13 residues relieves inhibition in vitro. This suggests that PP5 is an auto-inhibited enzyme and that the binding of a protein and/or lipid to the TPR domain may regulate PP5 activity in vivo. The TPR domain, by binding specific proteins, may also control substrate specificity and subcellular localization of PP5. To reveal potential functions for PP5 in the central nervous system, we identified specific brain regions that express high levels of PP5, including hippocampus, cortex, cerebellum, striatum, and the hypothalamus. This suggests PP5 may be involved in neuroendocrine secretion, memory formation or motor function, and also indicated that PP5 shares overlapping regional distribution with type II glucocorticoid receptors in brain. Since these receptors are putative targets for PP5 regulation in non-neuronal cells and are critical in nervous system development, stress responses and aging, we are now investigating whether PP5 and glucocorticoid receptors are co-localized at the cellular level within these brain regions. We have shown that PP5 may be an important tau phosphatase in brain. Since tau phosphorylation is thought to be important in the neurodegenerative processes underlying Alzheimers disease, these studies suggest that PP5 activity in neurons could help prevent the degenerative processes that lead to this debilitating disease. We have also initiated a proteomics study to identify cellular targets for PP5 in neurons and endocrine cells. Using a yeast 2 hybrid screen, we identified 3 novel potential binding partners for PP5; 2 of these proteins have features found in transcriptional regulators, and the third contains multiple repeated protein binding motifs found in scaffolding proteins.
- b. *Impact:* The information learned in these studies increases our understanding of how cellular excitation is controlled. The regulatory enzymes we have identified may be new drug targets for controlling ion channel function in the treatment of nervous, cardiovascular or endocrine disorders. In addition, these enzymes are also attacked by certain natural environmental toxins. Our work showing that these enzymes play an essential role in ion channel regulation reveals a potential path by which these environmental toxins may compromise nerve, muscle or endocrine cell function.
- c. *Source of Federal Funding:* Hatch, NIH

d. Scope of Impact: United States

Key Theme: Human Nutrition (1)

- a. Description:* This study focused on the effect of polysaccharides and oligosaccharides on the texture and other properties of foods. Work has also begun on quantitatively determining the texture of foods to be used in a study examining the effect of food texture/rheology on appetite, satiety and food intake behavior. A variety of foods have been examined by Brookfield viscometry at 22 degrees C. Water, Kool-Aid, physically degraded Jello gelatin gel, and SlimFast were compared for viscosity. Inulin is still being investigated to determine its effect on various starch gel systems. A series of wheat flour gels (4%, 6%, and 8%) were prepared either containing no inulin or containing inulin (inulin:flour ratio = 0.1). The samples were stored at -5 degrees C or 10 degrees C and assessed for changes in the texture over a period of 5 days. In the 4% gels (5 degrees C) the inulin had no effect on gel texture. At 6% there was a general tenderizing effect on the gel by the inulin component. For the 8% gel, the results were mixed. A preliminary investigation has been made into the toughening phenomenon that occurs in baked goods when they are subjected to microwave heating. Pancakes were prepared by a standard recipe and then frozen. After storage for 1-5 days the pancakes were subjected to heating to 60, 80, 100, and 120 seconds. Texture analyzer and water activity measurements were taken and regardless of storage time a very significant increase in texture analyzer penetration force was noted between 100 and 120 seconds (70 grams to 475 grams). A simultaneous decrease in water activity was noted (0.945 to 0.902).
- d. Impact:* The government recommendation for calories from fat in the diet is that it be no more than 30%. The average American diet typically has 35% of calories from fat. Reduction of calories by use of a fat replacer such as inulin has potentially significant health benefits. While it is known that there is an influence of viscosity on suppression of hunger in humans, little is known about potential mechanisms. This collaborative work seeks to look at foods of different textures to see if they have varying effects on satiety, hunger, sense of fullness and food intake behavior.
- c. Source of Federal funding:* Hatch
- d. Scope of Impact:* United States

Key Theme: Human Nutrition (2)

- a. Description:* This research project is examining methods to moderate starch digestion rate in foods with the aim of manipulating glycemic index, as well as lengthening duration of glucose (energy) release. Two processes, with refinement, we believe will be useful in slowing starch digestion rate: 1) controlled partial digestion of gelatinized and retrograded starch, followed by spray-drying, and 2) formation of protein webs during the cooking process that act to constrain swelling of gelatinizing starch. Further studies have been conducted on the latter process showing that treatment with alpha-amylase of sorghum-based 3-dimensional protein web-starch structures show slower starch digestion compared to similar cooked maize or rice-based pastes. Moreover, addition of an oxidant to maize or rice flour prior to cooking resulted in the formation of similar protein web and starch-associated structures, indicating that this technology is transferable to other starch-based foods than sorghum. Other related work showed that gelatinized starch that is associated with protein is generally digested slower than free gelatinized starch. In another project on slowly digestible starch, a previously identified soluble 3-component complex containing starch (amylose), free fatty acids, and soluble protein was shown to have an intermediate starch digestion rate compared to free amylose or free fatty acid-complexed amylose. Thus, this complex shows potential as a slowly digestible starch source for beverages.

- b. *Impact:* Although the low-carb craze appears to be dwindling, the role of rate of starch digestion in glycemic response and duration of postprandial glucose release will remain important due to a number of pressing public health problems. Low glycemic index foods show promise in addressing diabetes and pre-diabetes, cardiovascular disease, and even obesity. This is related to the new recommendations to include whole grain foods in the diet for improved health, as these foods contain fiber that helps to moderate starch digestion rate. In our laboratory, we are attempting to develop novel ways to slow starch digestion in formulated or processed foods through fundamental understanding of starch fine structure and interactions. This work, if successful, should provide a basis for introducing a slowly digestible starch property to a variety of foods.
- c. *Source of Federal funding:* USAID, USDA-ARS
- d. *Scope of Impact:* Global

Key Theme: Human Nutrition (3)

- a. *Description:* Our studies have focused on the role of fatty acids on lipid metabolism. Conjugated linoleic acid (CLA) has been shown to modify experimentally induced atherosclerosis, but has variable effects on cholesterol metabolism that appear to be dependent on the degree of saturation of the other lipids in the diet. Rats were fed a semipurified diet with either butter or corn oil supplying the lipid (4%) with and without 0.25% cholesterol added. Control butter (C/B) was compared with butter naturally high (about 0.16%) in CLA (CLA/B), butter with 0.16% commercial CLA (B/lowCLA), butter with 1% commercial CLA (B/highCLA), corn oil control (C/CO), corn oil with 0.16% CLA (CO/lowDLA), and corn oil with 1% CLA (CO/highCLA). After 4 weeks of feeding, serum and liver cholesterol, hepatic abundance of cholesterol 7[alpha] hydroxylase (CYP7A) mRNA and bile acid excretion were measured. Serum cholesterol was not significantly altered by any of the diet treatments. Liver cholesterol levels were significantly higher when cholesterol was added to the diet and higher with corn oil as a source of lipid when compared to butter. None of the CLA treatments had an effect on liver cholesterol levels. Bile acid excretion was higher with corn oil as a source of dietary lipids and tended to be higher with the highest level of CLA. These results would suggest that the "background" dietary lipids have an impact on the effect of CLA on cholesterol homeostasis.
- b. *Impact:* CLA and other polyunsaturated fatty acids which occur in our diets in limited quantities have been suggested to have an impact on cholesterol metabolism and/or atherosclerosis. This has led to development of functional foods containing higher levels of these fatty acids, some naturally occurring and some supplemented with the fatty acids. Our data suggest that the impact of these fatty acids may be modified by the other lipids in the diet and that the levels achievable by natural means are not likely to be sufficient to have an impact on this disease.
- c. *Source of Federal funding:* Hatch
- d. *Scope of Impact:* United States

Key Theme: Human Nutrition (4)

- a. *Description:* A total of 745 subjects participated in a Bone Health project. Approximately 425 midpoint measurement visits and 250 final measurement visits have occurred. Retention of subjects throughout the 18 month study duration has been excellent and overall, only 4.3 percent of subjects have not achieved full study participation. The Bone Health project curriculum was implemented in sixth grade school classrooms in six states across the country. During the 2002-2003 school years, 33 schools agreed to participate in the project and during the 2003-2004 school years 40 schools agreed to participate. A total

of 3,509 students participated in the Bone Health classroom project. During the second year of school implementation, a multiple choice, pre/post survey was introduced. This survey was administered at both intervention and control schools in two states. Data analysis of the pre/post survey results has shown a statistically significant change in subject knowledge between the intervention and control schools. The Bone Health multi-media curriculum was awarded the Association for Communication Excellence in Agriculture's Gold Award for the most innovative interactive.

- b. *Impact:* Monitoring and measuring adolescent girls in both intervention and control groups over a period of 18 months has helped determine the ability of a multi-media science curriculum to influence the food behavior, physical activity, and bone growth of the subject population. Continued piloting of the multi-media curriculum will provide further evidence to support current findings which show significant increase in knowledge following participation in the project sessions.
- c. *Source of Federal funding:* USDA-IFAFS
- d. *Scope of Impact:* United States

Key Theme: Human Nutrition (5)

- a. *Description:* Osteoporosis is the most readily identifiable health issue associated with inadequate calcium intake. Obtaining sufficient calcium during adolescence helps ensure adequate mineralization of the skeleton to ensure bone health later in life. Results obtained from a previous multistate project highlighted that familial factors play an important role in the calcium intake of youth. However, little information is known about these factors. This multistate project, involving 13 states, actively examined parental factors such as knowledge, attitudes, behaviors, and environment and their influence on calcium intake of children in early adolescence (11-14 years old) from race/ethnic groups most at risk for osteoporosis. Indiana completed 16 one-on-one scripted open-interviews and a forced-choice questionnaire on use of calcium dietary supplements and calcium fortified foods with parents/caretakers of young adolescent children. The respondents represented 15 females and 1 male that self-identified as Asian (n=4), Hispanic (n=4), or non-Hispanic White (n=8). Transcriptions of the interviews completed in Indiana were sent to Colorado for analyses using the software NVIVO. The Indiana site was responsible for compiling the characteristics of the interview participants from all 12 state sites, e.g., race/ethnic group, age of child, years in country, and language used in home. A total of 206 interviews of parents/caretakers were completed and respondents self-identified as Asian (n=48), Hispanic (n=44), non-Hispanic White (n=76), Black (n=2), and Mixed (n=36).
- b. *Impact:* The results from this project will be used to identify factors that influence the calcium consumption of early adolescents. The information can be used to design effective, tailored nutrition intervention for early adolescents and their parents. The improvement in calcium intake among early adolescents may reduce the burden of osteoporosis in the future. The information on parental factors influencing food intakes of their children is likely applicable to other health-related behaviors such as the development of obesity. Thus the messages found effective for improving bone health, may be useful for minimizing the development of obesity.
- c. *Source of Federal funding:* Hatch
- d. *Scope of Impact:* United States

Key Theme: Human Nutrition (6)

- a. *Description:* Evaluation of calcium absorption in the mouse model found that gender had a significant impact on vitamin D regulated calcium absorption and gene expression-- female mice were more responsive. The gender effect in mice is opposite of what others have seen in rats and humans. This means that one must be cautious when using mice as a model (and is a concern when one considers that genetically modified mice are becoming more common in the study of bone and calcium metabolism). Second, we have clarified additional mechanisms that may define the capacity of the intestine to absorb calcium from the diet. In one study we revealed the molecular mechanism for how intestinal cell development regulates expression of the calcium transport protein calbindin D9k. We also found that the vitamin D receptor in intestinal cells is fundamentally different from the vitamin D receptor in bone cells. The vitamin D receptor in intestinal cells is post-translationally modified and this appears to change the responsiveness of intestinal cells to the vitamin D hormone.
- b. *Impact:* Our work has extended the scientific understanding our how calcium absorption occurs and how vitamin D regulated that process. In addition, we are better defining the molecular determinants of regulation of intestinal calcium absorption.
- c. *Source of Federal funding:* Hatch, NIH
- d. *Scope of Impact:* Global

GOAL 4: GREATER HARMONY BETWEEN AGRICULTURE AND THE ENVIRONMENT

Overview: Purdue researchers continue to develop and test science and technology solutions for the conservation and management of 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.

Animal Waste Management and Air Quality- Reducing the environmental impact of animal agriculture through economically feasible means continues to be a significant part of Purdue's environmental research efforts. We are developing new ways to generate and test livestock feeding regimes and waste handling systems that reduce nutrients, particulates, and gases emitted from animal feeding operations. Purdue University is leading a national study partially funded by USEPA on air emissions from CAFO swine operations to provide a baseline for future air quality regulation.

Decision Support Tools- Many Purdue University researchers are using modeling to develop or improve environmental decision support tools for local governments and plan commissions, state and federal regulators, and producers. These programs are being used to predict and visualize the impact of land-use changes on polluted runoff and wildlife populations in the Midwest. Purdue is also a leader in nutrient management plan development software and continues to be the primary program supported by NRCS and EPA.

Biodiversity and Population Biology- Purdue University has significant efforts in the assessment and modeling of how wildlife populations are influenced by changes in habitat and adjacent land use. These studies are developing better recommendations for implementing BMPs to improve water quality, managing economically important fish populations in the Great Lakes, and minimizing wildlife damage to crops.

Integrated Pest Management- Pest management alternatives for urban and suburban environments, as well as for animal and crop production systems, are being explored by a number of Purdue University researchers. IPM

programs for schools and lawns developed at Purdue are controlling pests and protecting human health using economically and environmentally responsible means.

Under Goal 4, Purdue is continuing to provide the technologies, practices and systems needed to sustain and enhance our natural resources while addressing the productivity of agricultural operations and the development of stronger rural economies.

Successes:

- Expanded a web-based decision-support tool for predicting the impact of land use changes on runoff and non-point source pollution to include data for five Midwestern states in addition to Indiana.
- Developed models to predict any changes in wildlife populations resulting from proposed land use changes.
- Expanded use of Purdue's Manure Management Planner (MMP) software for developing nutrient management plans to 28 states (up from 22 last year).
- Developed BMP evaluation forms to help producers and watershed managers assess the usefulness of BMPs once they have been established for a number of years.
- Demonstrated that the lifespan of most BMPs is limited and watershed managers need to account for their continued maintenance or replacement.
- Discovered new factors that contribute to retention and excretion of nutrients in Pekin ducks, broiler hens, and pigs.
- Long-term studies of nitrogen and carbon pools in soils and subsurface drainage water have provided the first information on the mass of dissolved organic carbon lost in tile drainage as impacted by agricultural management systems.
- Established the world's most comprehensive collection of mayfly information, Mayfly Central, for use by water quality regulators, conservationists, ecologists, and others.
- Developed a model that can predict how changes in landscapes will influence a host of wildlife species found in the Midwest.

Benefits:

- Results of a long-term nitrogen and carbon pool study are being used to guide producers on optimizing crop management and to inform regulatory efforts targeted at implementing TMDLs and abating greenhouse gases with carbon sequestration.
- Researchers are helping animal producers reduce their potential for environmental impacts by providing new recommendations for animal feeding that are reducing water and air pollutants from manure.
- Utility companies, state transportation agencies, and municipalities can now save money and time by replacing manual pruning with tree growth regulators for managing trees and shrubs.
- Regulators and land managers are being provided with the tools they need to make better decisions and future land use that allow communities to grow and prosper while minimizing negative environmental impacts.

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 \$802,406 Federal formula funds and \$5.21 million of state funds plus 43 FTEs have been invested in Goal 4. This is a best estimate and these are not presented as auditable numbers.

Key Theme: Water Quality, Riparian Management (1)

- a. *Description:* Little is known about the long-term (i.e., many years after the project has ended) impacts of watershed management efforts, such as structural best management practices (BMPs). Purdue University researchers have developed evaluation methods that estimate the current condition of these practices based on visual inspection and comparison to selected original design dimensions for four structural BMPs: grassed waterways, grade stabilization structures, field borders and parallel terraces. The evaluation tools were tested for validity using an expert panel approach and for reliability based on inter-rater correlation. These evaluation tools were applied to a subset of structural BMPs implemented in the late 1970s in a major watershed management project in Indiana (the Black Creek Watershed). Researchers found that one-third of the BMPs no longer remain. Those BMPs that remain today are in fair condition and are reasonably functional. The study serves as a reminder that BMP functional life is limited, a fact that needs to be explicitly considered in conservation and watershed planning.
- b. *Impact:* This is one of only a few studies that have evaluated the impact of structural BMPs 20 years after their implementation. This study has raised awareness of the limited lifespan of such practices, and has changed the way we assist regulators and local officials develop watershed management plans by considering plans for eventual replacement or continued maintenance of such management measures.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Indiana

Key Theme: Sustainable Agriculture (1)

- a. *Description:* Most conflicts arising between agricultural and wildlife interests are likely caused by negative perceptions related to crop depredation by vertebrates. The development of viable solutions to such conflicts is the primary means to a more productive and sustainable coexistence between agriculture and wildlife in human-dominated landscapes. Purdue University researchers are quantifying crop depredation by wildlife species in corn and soybean fields from planting until harvest using multiple transect surveys of damage throughout the growing season. In addition, extensive telemetry data on target species including white-tailed deer, raccoons, and wild turkey have been collected throughout the study period to provide spatially explicit movement data for these species within the same landscape that is being surveyed for crop damage.
- b. *Impact:* Agricultural damage by wildlife species in the United States is substantial and widespread, and such damage is a serious concern to many agricultural producers. It has been estimated that wildlife-related, economic losses to agricultural producers (farmers and ranchers) currently exceed 4.5 billion dollars annually in the United States. Furthermore, results of nationwide surveys conducted in 1993 and 1994 indicate that 80% of farmers and ranchers suffered wildlife damage in the prior year, and 53% suffered damage that exceeded their tolerance. This work is providing agricultural producers and wildlife professionals with the information needed to make accurate assessments of the extent and source of wildlife-related damage to corn and soybeans in the Midwest which, in turn, allows them to develop sound management strategies for abating damage from wildlife.

- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Biodiversity (1)

- a. *Description:* Establishing the diversity and distribution of the Mayfly (order *Ephemeroptera*), an important group of freshwater insects, is needed for determining species at risk, habitats requiring monitoring or remedial action, and species best suited as indicators of water quality. The world's most comprehensive collection, electronic database, and literature sources for the study of mayflies have been established at Purdue University. Mayfly Central on the WWW is used as a resource and clearing house for mayfly information and management.
- b. *Impact:* Purdue University has provided a critical resource to agencies, organizations, and individuals interested in biodiversity, water quality, and wetland habitat conservation. State and federal agencies, conservation organizations and consultants use data provided by Purdue to make recommendations regarding mayfly species and aquatic habitats of concern. Mayfly Central is visited daily by ecologists, water quality specialists, environmental biologists, and others.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multi-state

Key Theme: Natural Resources Management (1)

- a. *Description:* In the urban landscape and along electrical distribution systems, trees and shrubs often grow too large for the available space. If unchecked trees and shrubs can interfere with power lines and property management and pose an even greater risk during adverse weather conditions. In the past, costly mechanical pruning was the sole management option available to the urban and utility-system forester. Chemical growth retardants are being investigated as inexpensive approaches to limit the size and growth rate of trees and shrubs. Although growth reduction is an important plant response and justifies the use of these compounds on urban trees, work at Purdue University has demonstrated that paclobutrazol and flurprimidol will alter the production of metabolic energy which alters not only growth, but prevents infection from fungal disease and improves drought tolerance.
- b. *Impact:* This research demonstrating the multiple benefits of tree growth regulators has led to an expansion of their use by the electric utility industry. The use of chemical growth regulators has reduced the need for expensive and costly mechanical pruning and for fungicide application while improving overall plant quality. Growth regulators are now recognized as an important chemical tool for the care and maintenance of all trees and shrubs in the landscape-- saving millions of dollars in management and replacement cost.
- c. *Source of Federal Funds:* McIntire- Stennis
- d. *Scope of Impact:* Multi-state

Key Themes: Biodiversity, Natural Resource Management (1)

- a. *Description:* Wildlife ecologists need to provide land-use planners and policy makers with information on how land-use decisions will alter natural habitats and are likely to affect wildlife populations and

communities. Researchers at Purdue University have finalized a 3-year project to collect the data needed to develop models for providing this information to stakeholders and others in the scientific community. Thirty-five 3x3 mile landscapes were sampled for birds, mammals, reptiles, and amphibians. Data were also collected on structural features of the local habitat. The data and structural features were combined into GIS data layers to allow a quantification of the patchiness of resources, the impact on animal diversity, and the degree to which the landscapes differ in landcover composition.

- b. *Impact:* We are unaware of any study of this scope that has been conducted in an agricultural landscape on such a wide variety of taxa. Completed models have provided the capability to predict how changes in landscapes influence occurrence and abundance of a host of wildlife species and will allow an informed decision making process saving both the natural resource and the costs associated with development. These models are allowing visualization of the effects and processes. Estimates from our study can account for detection error (i.e., labeling as absent at a site a species that was missed during sampling), something which is rarely done in wildlife studies. This information will be incorporated into decision tools to support land-use planning optimizing decision making while minimizing adverse environmental impacts.
- c. *Source of Federal Funds:* Hatch, USDA-IFAFS
- d. *Scope of Impact:* Multi-state

Key Theme: Integrated Pest Management, Pesticide Application (1)

- a. *Description:* Traditionally, pest management on home lawns has relied on the prophylactic use of synthetic compounds to manage anticipated pest problems. Concerns about human health risks and environmental impacts associated with this application strategy have forced practitioners to consider alternative management approaches. Unfortunately, adoption of Turfgrass Integrated Pest Management (IPM) has not been widespread because there is almost no data for valid comparisons between different management approaches. Researchers from Purdue University's turfgrass program have conducted two investigations to address this problem. The first involved monitoring turfgrass insect, weed, and disease problems in a set of 35 existing home lawns and providing valid comparisons of the relationships between lawn management practices and turfgrass pests. This work has revealed that weed infestation levels in homeowner managed lawns are similar to those in unmanaged lawns despite regular applications of herbicides formulated for homeowner use. The second line of research used a set of experimental lawns and existing turfgrass on which several different management methodologies have been implemented. The resulting stands were evaluated in biological (insects, weeds and diseases), economic (material and labor costs, and time), and aesthetic (acceptability) context in order to provide a broad basis for comparing different management approaches. In the controlled aspect of the study, 39 commercial lawn care professionals were asked to rate the plots. After several months, even those plots receiving the highest chemical inputs were rated as unacceptable by a large majority of lawn care professionals participating in the study. Data from these studies suggest that homeowners are misapplying pre-formulated retail products and that traditional application programs should be reevaluated. This points to the potentially large impact of providing more timely information to property owners and the need to develop turfgrass management programs designed for existing stands of turfgrass. These data also suggest that professional turfgrass managers should reevaluate their application programs for existing turfgrass as most plots receiving the highest levels of chemical input were rated as unacceptable due to weed and insect infestations.
- b. *Impact:* New education programs are being formulated based on this research to better inform landowners on methods that improve the efficacy of consumer implemented lawn management while reducing the frequency of chemical applications. This work is also shaping new Extension programs for

professional turfgrass managers that will stress the need for early implementation of management programs during lawn establishment in order to achieve expected turf quality. These projects have taken implementation of turfgrass IPM to the next step and will work to reduce over-application of pesticides and fertilizers to lawns.

- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multi-state

Key Theme: Agricultural Waste Management (1)

- a. *Description:* Agricultural fields can be non-point sources of phosphorus (P) pollution because fields with high levels of P (often from repeated manure applications) may release quantities of both soluble and bioavailable P via surface runoff, erosion, and leaching. Control of P in manure is best achieved by reducing the amount of P fed to the animal while concurrently increasing the animal's opportunity to utilize the delivered nutrient. Work at Purdue University is determining the effects of feeding phytase to animals to improve the uptake of P, which then reduces the P levels in manure. Results from this work indicate that phytase efficacy for *E. coli*-derived phytase-yeast propagation is substantially greater than current fungal phytases on the market for Pekin ducks. Other studies have investigated effects of feeding a reduced crude protein and phosphorus diet on grow-finish swine performance including carcass characteristics, manure concentration, and ammonia emissions in swine housing. Researchers devised a new low nutrient excretion (LNE) diet, formulated with reduced crude protein plus synthetic amino acids, low phytic acid corn, and phytase. Pigs fed this diet produced a numerically larger volume of manure per day, but excreted less ammonium-N, nitrogen, and phosphorus per pig per day and reduced average aerial ammonia concentrations by 36.5%.
- b. *Impact:* These projects have provided better ways to use diet reduction strategies to reduce the impact of P from animal manure in an economically feasible way. Use of modified diets reduces the land area needed to dispose of the waste as well as the negative environmental impacts and costs associated with waste transport. Reductions in aerial ammonium-N will help produce meet air quality regulations.
- c. *Source of Federal Funds:* Hatch, USDA-IFAFS, USDA-NRI
- d. *Scope of Impact:* Multi-state

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

Overview: The key to Goal 5 is to improve the quality of life by enhancing human capacity through education, developing leadership and delivery of information resource. Purdue University researchers have established information resources that will aid in enhancing the quality of life for the people of Indiana. Quality of life has a different meaning depending on people's values, interests, economic status, and background. Purdue University's role in developing information resources, services, and opportunities plays a key role in the development of the state's human capacity, generating employment opportunities, and contributing to economic growth. In fact, this is a top priority at Purdue University with direct leadership from the Office of the Provost. Engagement, following the recommendations of the Kellogg Report, with citizens across the state is helping Purdue University attract the necessary resources, despite the current weak economy, to create future economic opportunities in Indiana. The former Dean of Agriculture is currently the Vice-Provost for Engagement with responsibilities to extend all university educational resources to the citizens of Indiana.

A USDA-funded Agricultural Innovations Center composed of Purdue University researchers and county extension staff is helping farmers develop value-added business proposals. An ethanol plant and a food-grade corn processing plant are currently in the final planning and construction phases. Other studies are examining the potential for Indiana certified pork, 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. Agricultural economists have developed computer software that helps county government officials determine the fiscal impacts of local commercial, industrial, and residential development. This is very important information for local plan commissions, county commissioners, and state legislators as Indiana struggles to reduce a large budget deficit.

Successes

- Internet-based program allows students to set and monitor personal nutrition and fitness goals.
- Analysis of credit use by Indiana families should contribute to our understanding of welfare reform on rural, low-income families.
- A community case study on conflict resolution has provided insights on community-based ways to offer public input into natural resource management.

Benefits

- A fiscal impact model of the Indiana state budget offers alternatives to reduce a projected \$1.7 billion revenue shortfall over the next four years.
- A study with 51 preschool children developed methods for teachers to conduct more inclusive methods so that children with disabilities are not left out of educational activities.
- A secure retirement website offers 29 links to retirement planning information.

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 various local stakeholders, are providing information on alternatives for debt reduction, tax restructuring, and planning and zoning.

Resources:

Approximately \$209,440 Federal formula funds and \$991,392 state funds plus 7.5 FTEs have been invested in Goal 5. This is a best estimate and these are not presented as auditable numbers.

5A. Improved Quality of Life

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

- a. *Description:* An Internet-based program to help college students assess their food and physical activity choices was begun. Programming is expected to be completed by summer 2005 and offered in fall 2006. The program will eventually be offered in 3 or 4 nutrition courses at the university and be made available for use by other universities. The program also will be evaluated for acceptability for use in adult education programs offered through the Cooperative Extension Service. There is a need to provide adults with access to health and fitness assessment tools that allow them to set goals and measure progress.
- b. *Impact:* The Internet-based program will allow students to set nutrition and fitness goals and follow their progress in achieving these goals.

- c. *Source of Federal Funding:* Hatch and Smith-Lever
- d. *Scope of Impact:* National

Key Theme: Family Resource Management (1)

- a. *Description:* Credit management is a challenge for many families. Wave 3 data collection and transcription are complete; verification and cleaning of both the qualitative and quantitative data is on-going. Preliminary data analysis on credit use suggests that low-income Indiana families use several types of credit. Many report problems using pawn shops, rent-to-own, and pay-day loans.
- b. *Impact:* This project should make a significant contribution to our understanding of the impact of welfare reform on the well-being of rural, low-income families.
- c. *Source of Federal funding:* Hatch
- d. *Scope of Impact:* Indiana

Goal 5B: Individual, Family and Community Economic Development

Key Theme: Conflict Management (1)

- a. *Description:* Conflict management is a challenge for many community-based discussions of resource use. This study included 27 in-depth interviews with a watershed project participants and an examination of project documents, meeting minutes, monitoring reports, newspaper articles and on-line chatrooms. The project was fraught with conflict from its inception, with a local branch of a national farmer's group ultimately withdrawing its support for the project. Our preliminary conclusions suggest that the project's problems were based on a perceived lack of fairness in the process, little interpersonal trust and a history of ideological differences that the collaborative process could not overcome. One clear finding of this study, however, is that not all farmers shared the views of the activist farmer group. While a majority of farmers are members of this group, they did support the goals of the watershed project. However, when the farmer's group spoke out against the watershed project, it carried significant weight, as evidenced by newspaper articles and interviews with members of the steering committee. This calls into question what the notion 'representative stakeholder' really means. The President and Vice-President of the county chapter of the farmer's group both sat on the watershed project's steering committee, but they claimed they were there as individuals and they were not representing the group. However, in conversations with other farmers they constantly denigrated both the project and its goals. This case study highlights the difficulties of collaboration in a fragmented landscape. It also suggests a number of ways in which collaboration can be made stronger: 1) Leaders of collaborative processes must go above and beyond in their pursuit of fairness. They have to consider how both their public and their private actions can affect people's perceptions about their impartiality. When questions are raised during the process, they must be addressed to the satisfaction of all participants. 2) All stakeholders must be very clear and honest about who they represent. It is perhaps impossible to expect participants to remove all of their different hats when they enter a collaborative process. By acknowledging this difficulty, perhaps there can be less ambiguity in collaborative processes. 3) Historical and ideological conflicts must be openly discussed at the beginning of a collaborative process and the participants must agree to disagree about some things while still working together on others.
- b. *Impact:* A number of collaborative public processes related to natural resources are underway in Indiana. Collaboration is not an easy undertaking and a great deal of care must be taken in working with many

diverse stakeholders. Implementing the lessons from this case study can help make ongoing and future processes work more effectively which will benefit the entire state.

- c. *Source of Federal Funding:* Hatch
- d. *Scope of Impact:* Indiana

Key Theme: Impact of Change on Rural Communities (1)

- a. *Description:* A model of the Indiana state budget and its fiscal impact for Indiana counties, municipalities and school corporations was developed. In 2002-03, Indiana underwent a statewide property reassessment. Property was assessed based on 100% of market value, or predicted selling price. The data from this reassessment are only now becoming available. In addition, in November 2003 the state legislature altered the property tax controls. As of 2005-06 assessments will be updated annually, and as of 2006-07 business inventories will be exempt from property taxes. All of these policy changes have the potential to alter past results about the fiscal impacts on local budgets. A model of the Indiana state budget was designed to address the following problem. The 2001 recession and the end of the stock market boom caused a state revenue shortfall. Continued rapid growth in Medicaid spending and added property tax relief designed to soften the tax shifts from reassessment increased spending. Indiana exhausted its rainy day funds, and used up most available "fiscal gimmicks" for balancing the budget. The preliminary results of the state budget model imply that over the next four years, the state must raise \$1.7 billion more in revenues than it spends, in order to be prepared for the next recession.
- b. *Impact:* The fiscal impact model will benefit local decision-makers by allowing quicker and easier analysis of the fiscal impacts of development. Recent changes in assessment practices and property tax controls may alter the impacts on local budgets. The state budget was hit hard by the 2001 recession. A model of the state budget shows what must be done over the next four years to balance the Indiana state budget.
- c. *Source of Federal Funding:* Hatch and Smith-Lever
- d. *Scope of Impact:* Indiana

Key Theme: Parenting (1)

- a. *Description:* Fifty-one preschool children (22 boys) with a mean age of 50 months enrolled in two inclusive preschool programs participated in this project. Children participated in two individual interviews designed to assess children's ideas about including hypothetical peers with disabilities in play activities. In half of the interviews, the peer in the vignette was similar to the participating child in race and gender. In the other interviews, the peer in the vignette was different from the participating child. We also varied disability status of the hypothetical peers. We found that children were more likely to say that they would choose a child who has the same gender and race as their play partner (59% of choices) than a child with a different gender and race. There was a significant effect of story types, with children significantly more likely to choose a child with a disability as a play partner when that child was the same gender and race as the participating child. The results of this study provide evidence that children weigh a variety of different issues in making their choices: children were significantly more likely to choose a child with a disability than a typically developing child as similar to themselves when the child with a disability was the same gender and race. These findings build on results of a previous study in which we found that children were significantly more likely to choose a child with a disability as a playmate when the disability did not interfere with participation in the activity (e.g., doing puzzles for a child with a physical disability).

- b. *Impact:* The results of this series of studies will inform teachers' practices in inclusive programs. Understanding the ways in which social characteristics of groups, and demands of activities, influence children's ideas about including peers with disabilities will help identify effective teaching interventions that support participation of all children.
- c. *Source of Federal Funding:* Hatch
- d. *Scope of Impact:* United States

Key Theme: Retirement Planning (1)

- a. *Description:* Planning for A Secure Retirement, a distance education site, was developed in 2001 with funding from the Purdue University 21st Century Initiative. In 2002, the site was included in the Program Tool Kit of the Financial Security in Later Life website. Since the inception of Planning for A Secure Retirement, we have continued to expand the site by developing three additional sites. The accompanying sites are: A Retirement Estimator for Farm Families developed in 2002 and available at <http://www.ces.purdue.edu/farmretirement>, Who Will Get Grandpas Farm? Communicating about Farm Transfer developed in 2003 and available at <http://www2.ces.purdue.edu/farmtransfer>, and Getting Ready for Estate Planning developed in 2004 and available at <http://www2.ces.purdue.edu/estateplanning>. The Retirement Estimator is a calculator which allows users to enter income and expenses to determine if they can afford to retire. Who Will Get Grandpas Farm contains streaming video that illustrates how a farmer can communicate more successfully when discussing farm transfer with his father, his son, his brother, and his wife. The site includes an interactive quiz named Using What You Have Learned and a Presentation Guide that can be used by educators. Getting Ready for Estate Planning consists of six steps to help individuals learn about estate planning, clarify objectives, and collect information about their assets and liabilities before meeting with an attorney. All of the sites are also available on the Financial Security in Later Life web site. The sites have been featured in articles in Successful Farming and on the Successful Farming Radio Network. They have also been described in articles in the Journal of Extension. When asked to report on the use of sites in the Financial Security in Later Life Program Tool Kit in December, 2003, Cooperative Extension Service educators in several states reported that Planning for A Secure Retirement, A Retirement Estimator for Farm Families, and Who Will Get Grandpa's Farm were being utilized in presentations. In May 2004, the Financial Security in Later Life site received an Honorable Mention Award from the American Distance Education Consortium (ADEC). An important outcome of the web sites is the opportunity for collaboration with county, state, and national Extension staff in sharing programs.
- b. *Impact:* Planning for A Secure Retirement includes 29 interactive links to resources such as Social Security Benefits Checkup and other retirement planning information. Consumers and Cooperative Extension Service educators are able to use the site to obtain information and to develop retirement plans.
- c. *Source of Federal Funding:* Hatch and Smith-Lever
- d. *Scope of Impact:* Indiana

Key Theme: Home-based Business Education (1)

- a. *Description:* The focus of this study was on: 1) assessing family satisfaction and business success, and 2) characterizing the extent to which families intermingle their household and business funds, and the household, business and owner variables that are associated with intermingling by cosigning for business loans, or by lending household assets to the business. Results demonstrate that there are varying levels of

satisfaction with the family's business that are not necessarily related to the characteristics of the business. In short, not all households view their business results through the same lens. In terms of financial intermingling, we found household characteristics other than household net worth were not good predictors of the likelihood of intermingling. Instead, business characteristics such as business net worth, net income, education of owner/respondent, and number of employees were better predictors of the likelihood of intermingling. We compared family businesses to non-family businesses and found few differences in the factors related to intermingling. It appears that financial intermingling is not unique to family businesses, nor more likely to occur in family businesses. In addition, it is not necessarily limited to businesses in early start-up stages. Businesses of all sizes owed money to the owner's household suggesting either that household to business lending continues over long periods of time, or that businesses are not repaying debts to their owner's household in a timely fashion.

- b. *Impact:* Some spillover does exist from family to businesses (e.g., role confusion, financial intermingling, variation in satisfaction with the business), and families and their businesses may be at less risk if spillover is contained and boundaries that are satisfactory to the family members are maintained. Intermingling of finances between household and business can have an undue impact on the household at the same time that it supports the business. Recent reports have demonstrated that family businesses may be better performers than non-family businesses, therefore, it is important to understand how the presence of family in the business changes the business itself.
- c. *Source of Federal Funding:* Hatch and Smith-Lever
- d. *Scope of Impact:* Multi-state

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 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 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, etc. Staff participate in a wide variety of state and local events including conferences, commodity marketing associations, and agricultural interest group meetings. 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 or swine 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 Board. 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 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. Every session is evaluated by the participants.

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 Board and coordinates the transfer of soybean checkoff money to faculty under a competitive research grant arrangement. This relationship recently resulted in the funding to support two endowed faculty chairs- one in soybean genetics and one in soybean utilization. He also serves as Secretary for the Indiana Pork Producers Board. The Associate Director is a member of the Purdue University Institutional Review Board for human subjects' research. He also serves on the human subjects' subcommittee for Extension program evaluation statewide. This not only assures protection of human subjects, but links stakeholders, Extension educators, and researchers in program evaluation efforts.

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 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 2004. 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 soundboard for ideas with a wide array of diverse clientele.

College of Agriculture Roadmapping

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 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. Stakeholders were asked to respond to three questions: 1) What is the current state of Purdue's agricultural programs?, 2) What should the future look like?, and 3) What steps would be needed to get there? Issues discussed included diversity, research needs, agricultural issues of the future, and economic development. They also helped identify 14 different issue areas to be developed into action plans. 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. The Colleges of Agriculture, Veterinary Medicine, and Consumer and Family Sciences are all benefiting from these new faculty hires. To date about 35 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. Last year nearly one-half of the new faculty hires represented women and/or minority hires. This will help Purdue University better reflect the profile of stakeholders that we serve statewide. During 2004, 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 currently under construction.

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 2004, 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 Board 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-officio* 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 Laboratory which offers educational programs to crop protection professionals.

Office of the Commissioner of Agriculture

In Indiana, most state regulatory functions are located on the West Lafayette campus, e.g., Animal Disease Diagnostic Laboratory and the State Chemists Office. The Lt. Governor serves as the Commissioner of Agriculture. 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. Also Mr. Jim Mosley, Deputy U.S.

Secretary of Agriculture, is an Indiana farmer and is in frequent contact with Purdue University officials on a variety of topics such as bioterrorism.

The Indiana Commissioner of Agriculture's Office manages value-added funds authorized by the Indiana General Assembly. Purdue University administrators assist in the allocation of these funds, some of which provide support for Purdue University faculty to conduct research and extension programs that enhance income to farmers and rural communities. Projects range from research to improve beef quality to sponsorship of the Indiana Wine Festival and agro-tourism to educational programs to develop community kitchens for small farmers.

Commodity and Farm Organizations

Purdue University has a close working relationship with various stakeholders through commodity and general farm organizations including the Indiana Soybean Association, Indiana Corn Growers Association, Indiana Pork Producers, Indiana Wine and Grape Council, Indiana Farmers Union, 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 most cases. However, multi-investigator Hatch, Animal Health, and McIntire-Stennis projects are considered on a case by case basis where multidisciplinary teams are appropriate. Every 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 CSREES National Program Leaders have been approved. Also for FY2004 100% of the faculty completed prior to the submission deadline their annual CRIS reports—a total of 350 CRIS reports including NRI grants and multi-state projects.

D. EVALUATION OF SUCCESS OF MULTI AND JOINT ACTIVITIES

Faculty associated with the Office of Agricultural Research Programs at Purdue University are involved in over 100 multi-state projects managed through the four Regional Experiment Station Executive Director offices. These 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 of those faculty associated with each approved multi-state research meeting. The Associate Director of Agricultural Research Programs is the past chair, and remains a member, of the North Central Multi-State Research Committee. Hence, Purdue University is a major and active player in multi-state research activities, including several that involve integrated research-extension program efforts.

Purdue University is participating in a multi-state project (NC1003) designed to develop information to be used by public sector research administrators and other groups interested in the acquisition of resources for research, in planning and evaluating research, and in managing public research for the maximum benefits to society. A special publication was generated for administrators as a result of the proposed reduction in and reallocation of Federal formula research funds. This information will assist individual research administrators, regional associations of experiment station directors, legislative aids, OMB, directors of the CGIAR system and administrators of the individual international agricultural research centers, and other organizations in the financing, planning, managing, and evaluating public sector agricultural research. Information generated by the project will be useful

to private firms concerned with supplying farm inputs, transportation, storage, and processing of food and agricultural products; and to Congressional committees who appropriate funds and exercise oversight for federally funded research. Special attention has been directed towards management of intellectual property rights by public research institutions, especially as the result of research discoveries in biotechnology. Members of the group have addressed questions of consumer acceptance, income distribution implications, consequences for low-income farmers in developing countries, and international trade impacts.

Soybean rust, now widespread in Brazil, has the potential to become a devastating disease in the United States in 2005. Purdue University is an active participant in NC-505, a Rapid Response Research Activity committee. This effort is coordinating the assembly of information among USDA-ARS and land-grant scientists through email exchanges, climatological modeling efforts on air mass movements from the U.S. South to the Midwest that could carry the disease spores, survey design for detection, access to informational websites, research contacts in South America, techniques for potential eradication efforts, and development of educational materials for soybean rust identification and control including approved fungicides, application procedures, and economic thresholds. Frequent scientific exchanges have occurred on the Asian rust issue among Purdue and Brazilian scientists, several of whom received their doctoral training at Purdue University.

The soybean aphid, *Aphis glycines Matsumura*, is a new invasive pest in the upper Midwest including Indiana. Purdue University is playing a leadership role in a multi-state collaborative effort to define sampling protocols, economic thresholds, aphid-natural enemy ecology, and primary-secondary hosts associations. Sampling and threshold data are still under analysis, but a threshold level of ca. 200-400 aphids/plant seems to be a reasonable approximation. Further studies on predation, prey density, plant size, predator and prey dispersion patterns, and alternative prey are planned. The Field Crops Pest Management Project evaluated the impacts of planting date and insecticide application on aphid colonization. The team conducted foreign exploration and quarantine testing of soybean aphid natural enemies from China and Japan, and evaluated the impacts of existing natural enemies on soybean aphid population regulation. Biological control educational activities have impacted more than 500,000 students, educators, farmers, natural resource managers, IPM practitioners, policy makers and biological control specialists with diverse educational efforts including an electronic newsletter, website, extension and technical publications, presentations and sponsored symposia addressing diverse biological control topics. Several project scientists, include Purdue University, made significant contributions to a special edition of the March issue of the Iowa Soybean Digest on soybean aphid detection and management. A Purdue entomologist has lead a successful effort to obtain soybean check-off money for a large multi-state project on bio-control of soybean aphids.

A multi-state project (NCDC205) is addressing farmer concerns about the significant reduction in alfalfa stand life caused by pests and other factors. Results from Ohio and Indiana indicate that death of alfalfa plants is primarily occurring during the growing season instead of over winter. This is in sharp contrast to the generally accepted belief that winter killing is the primary reason alfalfa stands decline over time. Ohio data indicates that pathogenic fungi (*Fusarium spp.*) may contribute to stand decline in summer. Indiana data show that nutrient imbalance (high P levels without K fertilization) accelerates stand decline.

NCR-89 has focused on management strategies to improve pig performance and welfare. Statistical analysis of a sow step-up feed management study involving more than 200 sows will enable swine producers to better manage sow body condition and reproductive performance through nutrition management. Also results of a study on the removal and remixing of heavy weight finishing pigs can help ensure maximum profits by allowing for uniform groups of pigs to be marketed.

F. INTEGRATED RESEARCH AND EXTENSION ACTIVITIES

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

Institute Purdue University
State Indiana

Check One:
 Multistate Extension Activities
 Integrated Activities (Hatch Act Funds)
 Integrated Activities (Smith-Lever Act Funds)

Actual Expenditures

Title of Planned Program/Activity	FY2000	FY2001	FY2002	FY2003	FY2004
An Extension Guide for Interpreting Nitrate Concentration in the Tile Drainage Water					30,633.00
Genetics of Pork Growth and Swine Lean Growth					15,265.12
Using Dietary Acids as Alternatives to Antibiotics					21,930.90
The Effect of Co-Mingling Litters on Piglet Behavioral and Welfare					4,624.15
Determining Non-Laying Hens					20,548.00
A Cooperative Partnership for Small to Medium-sized Beef Producers in the Eastern Corn Belt: Phase I					12,581.82
Alfalfa Yield Improvement					8,953.80
Leadership in Drainage Water Management in Indiana					15,907.33
Strip Tillage and Nutrient Banding: A Systems Approach with High Potential					10,229.49
Growing Organic Apples					9,750.00
Improving Food Safety in Indiana Apples					6,961.95
CystX Soybean Varieties Increase Financial Return to Farmers					67,405.43
Information Systems for Environmental and Natural Resource Management					11,840.20
Total					236,631.19

March 1, 2005**Form CSREES-REPT (2/00)**

An Extension Guide for Interpreting Nitrate Concentration in Tile Drainage Water

The combined objectives of maximum corn yields, efficient use of inputs including fertilizer and improved water quality in agricultural watersheds has led to both agricultural and regulatory industry interest in measuring nitrate nitrogen ($\text{NO}_3\text{-N}$) concentrations in field drainage tile outlets. Crop, soil, and fertilizer management practices can have a strong influence on the amount of nitrogen (N) that is leached through soil and susceptible to loss in tile drainflow. However, other factors beyond a farmer's control can also strongly influence $\text{NO}_3\text{-N}$ leaching and these need to be considered when attempting to evaluate success of N management practices based on $\text{NO}_3\text{-N}$ concentrations measured in tile drainflow. Because of the importance of both tile drainage and nitrogen fertilizer to corn production in the Eastern Cornbelt, $\text{NO}_3\text{-N}$ concentrations in tile drainage water have been studied extensively by university researchers. Purdue University staff have developed an Agronomy Guide publication for technical personnel in the agriculture industry and conservation professions. The purpose of this publication is to provide some general guidelines for interpreting measured $\text{NO}_3\text{-N}$ concentrations in drainflow samples collected through monitoring programs, and to describe the most important factors influencing drainflow $\text{NO}_3\text{-N}$ concentrations. Collectively, numerous experimental results from university researchers suggest some common guidelines for interpreting the meaning of results from water testing programs. This publication translates this research information into a technical bulletin that permits individuals involved in public or private water monitoring efforts to draw scientifically supported conclusions about potential linkages between agricultural land management and surface water quality.

Genetics of Pork Quality and Swine Lean Growth

Ractopamine (Paylean™), a feed additive, increases lean growth and carcass lean percentage. The response to Paylean™ decreases with duration of feeding. Pigs outside the pork processors optimal carcass weight range are heavily discounted. For this reason, many pork processors sell 20-30 % of their fastest growing pigs prior to the start of Paylean™ feeding. The economic benefits of Paylean™ feeding can be increased if the duration of the response could be increased another one to two weeks. A research trial was completed comparing a Paylean™ step-up program to a control treatment. The data were used to refine the lysine requirements for pigs fed the increased concentration of Paylean™. The research results validated the model predictions that lysine essential amino acid requirements are higher for Paylean™ fed pigs than control pigs and the lysine requirement does not drop as in the case of control pigs or pigs fed diets containing a constant dietary concentration of Paylean™. The data indicated Paylean™ step-up programs can extend the duration of the Paylean™ response. Currently, 50% of all market pigs (50 million) are being fed Paylean™. Step-up programs can increase returns from \$0.80 to \$1.10 per pig over pigs fed constant levels of Paylean™. Currently, 20% of the producers using Paylean™ have switched to using a step-up program. The feeding of Paylean™ increases carcass lean growth and increases carcass lean mass by 7 to 10 percent improving pork processing efficiency. Pork producers need guidance in the optimal use of Paylean™ for their specific economic and marketing situation. The results of the stochastic pig growth model have been used to demonstrate how dietary lysine concentrations and marketing strategies change with the feeding of Paylean™.

Using Dietary Acids as Alternatives to Antibiotics

For several decades, antibiotic growth promoters have been used in diets of young pigs to reduce the incidences of post-weaning diarrhea and enhance growth performance. Because of the development of resistance in a number of pathogenic bacterial species, precautionary actions have been taken recently in Europe and to a lesser extent in the United States to exclude several antibiotics from pig diets. Organic and inorganic acids and their salts are potential alternatives to in-feed antibiotics to improve the performance of weaned piglets. Additionally, recent interest has focused on the acidification of drinking water as a means of combating reduced growth performance of nursery pigs associated with the post-weaning lag. The objective of this study was to evaluate the effects of diet and water acidification on the growth performance, microbial shedding, and fecal pH of nursery pigs. This study

utilized 205 pigs in a 34 day nursery trial to evaluate the effects of diet and water acidification on weanling pig growth and microbial shedding. Pigs (~19.2 days of age) were assigned to one of three dietary treatments: 1) Basal negative control diet; 2) Diet 1 + 55 ppm carbadox; 3) Dietary acid; diet 1 + .4% organic acid based blend (fumaric, lactate, citric, propionic, and benzoic acids) for days 0-7 followed by .2% inorganic acid based blend (phosphoric, fumaric, lactic, and citric acids) for days 7-34. These three diets were factored with or without water acidification of .33 oz/gal of a propionic and acetic acid based blend (KEM SANTM). Pen FI and individual body weight were recorded weekly. Treatments were fed in three phases: days 0-7, 7-21, 21-34. Feces were collected on days 6, 20 and 33 (3 pigs/pen) for measurement of pH and E.coli. No treatment effects were observed during phase 1. During phase 2, pigs fed carbadox had greater ADG and G:F than pigs fed dietary acids and tended to have greater ADG than pigs fed the negative control. During phase 3 and overall, pigs fed carbadox had greater ADG (overall; .857 vs .767 and .766 lb/day, respectively), ADFI and day 34 BW (41.3 vs 38.2 and 38.2 lb, respectively) than pigs fed the negative control and dietary acids. Phase 3 ADG was improved by water acidification across all diets, while water acidification increased ADFI only in pigs fed carbadox and negative control diets, but not dietary acids. Feeding carbadox tended to reduce E.coli on day 33 compared with pigs fed dietary acids. Pigs fed dietary acids tended to have lower fecal pH than pigs fed carbadox on day 20. Pigs receiving water acidification tended to have lower fecal pH than pigs receiving no water acidification on day 33. In collusion, pigs fed carbadox were 3.1 lb heavier at day 34 post-weaning than both negative control and dietary acids. The combination of dietary acids with water acidification resulted in decreased ADFI and overall growth performance, while all other treatment combinations improved pig growth above the non-antibiotic negative control alone. The use of water acidification in this study indicates that it has a greater potential to improve pig performance in a diet containing no antibiotics than dietary acidification and may reduce microbial shedding. The addition of water acidification improved the performance of the weanling pigs fed a non-antibiotic control diet, such that these pigs were nearly 2 lb heavier than the negative control pigs without water acidification, recovering 50% of the lost performance relative to a positive antibiotic control. The separate use of either dietary and water acidification has the potential to increase nursery pig performance and may further improve pig performance when these pigs are already being fed an antibiotic based on the results of this study. However, over acidification with both water and dietary acids will decrease pig feed intake and growth performance.

The Effect of Co-mingling Litters on Piglet Behavioral and Welfare

The U.S. swine industry is under considerable pressure to consider alternative housing methods which may improve animal welfare. Co-mingling litters prior to weaning has been shown to improve the welfare of piglets after weaning. Changes in piglet behavior and physiology which may explain this phenomenon is presently unknown. An experiment has been completed to examine how co-mingling litters prior to weaning influences behavioral development, growth and their response to various behavioral tests. Co-mingled piglets grew at the same rate as control piglets and were more adapted to social challenges before weaning. The results indicate that co-mingling piglets prior to weaning alters behavioral development in a manner that improves animal welfare. Results indicate that co-mingled litters were just as productive, but had improved responses to social challenges. Co-mingling litters may improve welfare with little negative economic impact.

Determining Non-Laying Hens

In the United States, there are nearly 300 million layer hens which produce table eggs. On average, approximately 216 million layers producing eggs (72%) or put another way, 28% which equals nearly 84 million layers did not produce an egg. Purdue research is focused on how to identify these “non-layers or low-producing hens”. A Purdue Extension Specialist has devised a non-invasive way via feed additives to correctly identify non-laying or low-producing hens. By correctly identifying these hens, producers could save money on feed cost, disposal of the birds, and improve the environment by directly reducing the amount of manure discharge when these birds are removed. In addition, there is now a technique to enhance yolk appearance in eggs. This may provide value to producers through niche markets. Through this method of selection, producers can effectively reduce 1-5% of the non-layers in a layer flock, which in turn increases the overall profitability of a layer operation; that is, when the

layers are removed, the direct cost of feed will be reduced proportionally and thus producers will realize a greater profit margin on the remaining birds as well as a reduction in manure discharge.

A Cooperative Partnership for Small to Medium-sized Beef Producers in the Eastern Corn Belt: Phase I

The Five State Beef Initiative (FSBI) has been a partnership between the Land Grant Universities, Cattlemen's Associations, State Departments of Agriculture, and Farm Bureau in Illinois, Indiana, Kentucky, Michigan and Ohio, plus United Producers, Inc., a producer owned livestock marketing cooperative. This partnership was created to develop a vertically coordinated beef production and marketing system that would increase producer profit by meeting consumer demand for high quality beef products. A feedlot project was initiated in 2003 and completed in late 2004. A final report was created for Phase II of this project and submitted to USDA/Rural Development in early 2004. Two meetings of the Five State Beef Initiative Board of Directors were held to discuss accomplishments and plan the future. The FSBI has certified 1438 producers and 2060 bulls and tagged over 22,100 calves. This project has changed producer mindsets and resulted in a number of secondary alliances, joint ventures and partnerships that have adopted appropriate aspects of the FSBI model. Examples would include the Manager Beef Alliance (MBA) program offered by United Producers, Inc. as well as several county, state, and regional branded beef initiatives. One of the significant impacts of FSBI activities is the building of cooperation among partner groups in creating regional resources, an education network, a business structure that serves producers in the region, and a transferable model that can be utilized by other agricultural commodities. Stakeholders have gained an understanding and appreciation of the value and importance of unique electronic animal identification for benchmarking, disease trace-back, and data sharing between industry segments; beef quality assurance and how it can affect product quality; and the importance of genetics, animal well-being, environmental stewardship, and working together to meet consumer expectations and changing industry needs.

Alfalfa Yield Improvement

How environment and genetics interact to alter alfalfa forage yield is not well understood. An 8-year long study to follow forage yield and its components from seeding (1997) to demise (2004) of an alfalfa stand was conducted. Fertilizer application was varied in hope of accelerating stand death or improving plant persistence. If alfalfa yield components (plant/ft²; shoots/plant; mass/shoot) respond to application of phosphorus and potash were better understood, researchers would be in a position to create new varieties that are more responsive to fertilizer applications. Knowing critical soil test and tissue test values, below which forage yield will be limited by nutrients, will allow Extension staff to advise producers on appropriate corrective applications of P and K. In addition, it will prevent application of excessive amounts of these nutrients that would reduce profitability or might pose a risk to the environment. In addition, by comparing P and K levels of soil tests, tissue analyses, and yield, producers will have information on the fertility needs of their individual fields. Plant persistence (number per square foot), shoot numbers per plant, and how massive individual shoots respond to 20 combinations of P and K fertilizer application were examined. The increased forage yield of alfalfa was due in large part to increased mass per shoot. Because fertilizer-responsiveness is closely associated with greater shoot mass, cultivars possessing this trait may be relatively more productive under well-fertilized conditions. Soil test and tissue test values that are necessary for high forage yield are currently being evaluated.

Leadership in Drainage Water Management in Indiana

Subsurface tile drainage of crop land is a major source of the nitrate load in the Mississippi River Basin and has been linked to hypoxia in the Gulf of Mexico. Research in other states had suggested that managing drainage through the use of water control structures in winter can substantially reduce nitrate loss through tile drains. Another potential benefit (which has little research verification) is that raising the drainage outlet in the growing season may save enough water to boost crop yields. Indiana has one of the highest percentages in the United States of crop land with subsurface drainage, yet little of the drainage was managed with control structures, and no Indiana research is evaluating this practice. Purdue University researchers participate in the national

Agricultural Drainage Management Systems Task Force, a partnership of USDA Agricultural Research Service (ARS), Natural Resources Conservation Service (NRCS), and land grant university faculty. This group has met several times each year since 2002 to develop strategies for improving drainage practices to reduce adverse impacts while enhancing crop production and conserving water. A proposal was written to USDA-CSREES to research the water quality, soil quality, and farm profitability impacts on four Indiana farms. The project, which was funded, will help to determine the yield, soil quality and other private benefits of drainage water management on corn and soybean cropping systems, and the impact of widespread adoption of the practice on nitrate loss at the watershed level. The integrated water quality grant enables the researchers to install and monitor paired field on-farm trials of drainage water management systems on four Indiana farms. Data collection, initiated the end of 2004, will enable us to compare nitrate loads during the 2004-2005 drainage season, and to compare crop yields in the 2005 growing season. Education on drainage water management practice is being carried out through many means including the Field Day at Davis-PAC, publicity for the field day which reached a much wider audience, discussions at meetings such as the NRCS State Technical Committee, and planned education of all NRCS county staff. Few people in Indiana had heard about drainage water management in 2003, but now agencies and industry are showing widespread interest in the practice. Our research will assist Federal, state, local, and non-governmental soil conservation and water quality organizations in making decisions on drainage water management promotion, and it will help growers faced with the choice of initiating drainage water management on their land.

Strip Tillage and Nutrient Banding: A Systems Approach with High Potential

Although the adoption of no-till cropping is greater in Indiana than in many other Corn Belt states, no-till adoption is very unevenly divided between soybean (near 60%) and corn (near 20%). That unequal adoption also occurs in other parts of the Corn Belt. Some of the reasons for lower no-till adoption in corn involve producer concerns for planting delays, nutrient stratification, uneven plant establishment and lower yields. Unfortunately, the tillage systems used prior to corn all too often are deep, intensive and result in very little protective residue cover on the soil surface. Furthermore, under such tillage management, the soil structure benefits that accrue with no-till during rotation crops are often negated when corn is produced. Purdue University has been conducting applied field research on strip tillage for over 15 years, and has been a keen advocate for its adoption. Strip tillage is a system that preserves most of the residue cover benefits of no-till while providing the additional advantages of facilitating deep nutrient banding, and achieving earlier soil drying in spring, warmer seedbeds for young corn seedlings, and improved yield consistency - relative to conventional tillage systems - for corn on many soils. Many corn producers are now using strip tillage as an alternative to both direct no-till and conventional tillage primarily because of the improved seed environment and increased planting flexibility it offers. Purdue University recommendations have assisted many producers and crop consultants with decisions regarding tillage timing, shank depth, banded nutrient rates, and general nutrient management for the crop rotation cycle when strip tillage alternates with another tillage system for rotation crops like soybean or wheat. The joint benefits of strip tillage and simultaneous nutrient banding have been carefully researched, and the tentative conclusions about this promising system have been widely shared to the agricultural community in several countries. Farmer adoption of strip tillage is increasing, and this has helped to counteract some of the slow adoption of the no-till system itself for corn.

Growing Organic Apples

Some commercial apple growers are looking to grow organic apples. The Food Quality Protection Act is likely to severely reduce the availability of pesticides that are essential to conventional apple growers. Investigating organic methods may provide us with non-chemical alternatives that could be used by conventional growers. Also, there is a lot of interest in growing organic apples, but no one really knows how to do it well. Because of the many disease and insect pests that attack apples it is imperative to use disease and insect resistant apple varieties; unfortunately, there are no apple varieties that resist all diseases or all insects. Growers must therefore use a combination of plant resistance and environmentally friendly pesticides to produce organic apples. Research at

Purdue University will provide the best of such combinations. This past year researchers continued to monitor for disease occurrence and severity on those cultivars within the apple scab resistant plots. Previous and current year data indicate that major disease problems for organically grown apples in Indiana will be apple scab, fire blight and sooty blotch and flyspeck. In addition, field trials using new 'organic' products for the control of apple scab and sooty blotch and flyspeck were incorporated into our ongoing organic fungicide program in which the strobilurin fungicide, Sovran, is used as the standard. Field data from this year's research will help determine how commercial Indiana apple growers can produce the highest quality organic apples with the least amount of pesticides. Current research is making the goal of growing organic apples more attainable for Midwest growers. Research continues to look at new 'organic' products to control some of the more common insect and disease problems encountered in Indiana and other Midwest states. By using a combination of minimal sprays along with safer 'organic' products we are closer to our goal of growing organic apples.

Improving Food Safety in Indiana Apples

Indiana apple growers have relied on organophosphate insecticides to manage many serious pests that attack their crop. In 1994, organophosphate insecticides accounted for 84% of the insecticides used on Indiana apples. The EPA has expressed concern about the potential impact of these insecticides on human health, especially children. There was a need to discover how Indiana apple growers could use less toxic insecticides for insect control and, at the same time, improve the safety of Indiana apples. In 1994, Purdue scientists conducted a pesticide use survey of Indiana apple growers to establish a baseline against which to compare future use patterns. Since then, we have conducted numerous field experiments to evaluate possible alternative strategies for managing insect pests of apples without using organophosphate insecticides. The researchers used extension workshops and meetings, presentations at professional meetings, extension newsletters, and one on one consultation to teach Indiana apple growers new methods for controlling insect pests. Purdue University scientists conducted a follow-up survey in 2002 to measure changes in insecticide use. Purdue University scientists conducted field experiments to find less toxic insecticides for Indiana apple growers. Growers were taught how to best use these alternative insecticide so that they could still produce a marketable crop through workshops, newsletters, and consultations. Use of alternative insecticides increased by 69% from 1994 to 2002, and accounted for 27% of the total insecticide use on apples. Testimonials from growers and pesticide sales personnel indicate that in 2004, there was a dramatic shift in pesticide use, away from the organophosphate insecticides toward safer alternatives. An additional pesticide use survey will be conducted during the winter of 2004 - 05 to document the additional changes in pesticide use

CystX Soybean Varieties Increase Financial Return to Farmers

Over 60,000,000 acres in the United States are infested with soybean cyst nematode (SCN), which is best managed by planting resistant varieties of soybeans. Researchers at Purdue University and the Indiana Crop Improvement Association (ICIA), with partial support from the Indiana Soybean Board (ISB), discovered and developed the PUSCN14 germplasm, which has complete and broad-based resistance to SCN and can be incorporated into high-yielding soybean lines with no yield drag. Access Plant Technology licensed, and is marketing, the patented new technology to soybean seed companies under their registered logo, CystX. Many farmer yield reports for CystX varieties are now available from several states with heavy SCN infestations, including Indiana, Illinois, Missouri, Arkansas, and Iowa. These farmers report production increases from 3 to 18 bu/A for CystX varieties as compared with the best SCN resistant varieties previously available. At a soybean price of \$5/bu, these yield increases equal \$15 - \$90/A. The number of soybean developing companies that are commercializing CystX varieties will double from three to six in 2005. About 90% of the CystX varieties currently available are stacked with RoundUp Ready.

Information Systems for Environmental and Natural Resource Management

Non-point source (NPS) pollution causes tens of billions of dollars in damage worldwide each year. Due to the diffuse nature of NPS pollution, identification of the most problematic areas can be difficult. The identification of local watershed boundaries is often required in assessing local hydrology and water quality issues. A WWW-based watershed delineation capability has been created and interfaced with a WWW GIS tool and hydrologic/water quality models (<http://pasture.ecn.purdue.edu/~watergen/>). The system allows users to zoom in on a WWW browse to a location of interest, view GIS data, select a watershed outlet (any point on a stream), obtain an estimate of the watershed boundary, obtain watershed characteristics, and run hydrologic/water quality models for the watershed. The WWW-watershed delineation capability allows users to quickly and easily obtain estimates of local watershed boundaries for any location of interest. The watershed and its properties can be used within hydrologic and water quality models interfaced with the system to identify water quality issues. The decision support system greatly simplifies the identification of water quality issues and potential solutions. Analysis of land values from 2000 through 2003 for north central Indiana reveal that development values for land in and around urbanizing areas can exceed \$15,000 per acre. The high land prices reduce the cost effectiveness of land use programs designed to improve water quality.