

**Annual Report of Accomplishments
And Results**

**Agricultural Research Programs
Purdue University**

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TABLE OF CONTENTS

	Page
A. PLANNED PROGRAMS	3
Program/Goal 1: An Agricultural Production System that is Highly Competitive in the Global Economy.....	3
A. <i>Integrated and Sustainable Crop and Livestock Production Systems</i>	7
B. <i>Genetic Resource Development</i>	10
C. <i>Plant Stress Management</i>	12
D. <i>Animal Disease, Health, and Well-Being</i>	14
E. <i>Farm Business Management, Economics and Marketing</i>	14
F. <i>Value Added</i>	15
Program/Goal 2: Safe and Secure Food and Fiber System.....	18
Program/Goal 3: A Healthy, Well Nourished Population.....	22
Program/Goal 4: Greater Harmony Between Agriculture and the Environment.....	26
Program/Goal 5: Enhanced Economic Opportunity and Quality of Life for Americans.....	34
A. <i>Improved Quality of Life</i>	35
B. <i>Individual, Family and Community Economic Development</i>	36
B. STAKEHOLDER INPUT PROCESS	38
C. PROGRAM REVIEW PROCESS	40
D. EVALUATION OF SUCCESS OF MULTI & JOINT ACTIVITIES	40
E. INTEGRATED RESEARCH AND EXTENSION ACTIVITIES	43

A. PLANNED PROGRAMS

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

Overview: Sustainable crop, livestock, and natural resource systems are important in Indiana. The economic value of agriculture in Indiana is approximately 2/3 plant based and 1/3 animal based. The challenge to farmers is to practice agricultural production in a way that is consistent with environmental quality while remaining competitive in a global economy. Many new agricultural production technologies and systems are being developed by the public and private sectors. Creating or operating in a sustainable framework and applying new technologies and systems are farmer dependent decision, and adoption will vary greatly across a highly diverse landscape.

Genetics and biotechnology are 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. Production agriculture is being transformed through the development of new genetic resources. For example, in 2001 12% of the field corn and 78% of the soybeans produced in Indiana were transgenic varieties. Purdue 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 scientists are engaged in a wide array of genetic research including development of DNA vaccines for poultry, Arabidopsis gene function discovery, and isolation of genes responsible for aggressive behavior in bees, poultry, and swine. 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. These stresses represent an economic risk to producers. Purdue agriculture is making a significant investment in research to mitigate the impact of potential losses by developing appropriate technology and systems. Pests adapt and evolve to counter control strategies, for example, the Western corn rootworm evolved to lay eggs in soybean fields thus causing problems in first year corn and negating rotation as a biological control measure. New pests, invasive species regularly enter agricultural systems, for example, the soybean aphid in 2000. Purdue researchers are exploring a variety of approaches to reduce potential pest loss including genetic resistance to pests, management on a wide area basis versus single field, modified production systems, biological control, chemical treatments, etc.

Regulatory developments are providing a significant challenge for pest management systems. The 1996 Food Quality Protection Act has resulted in the cancellation of pesticides important in agricultural production. Also, public opinion and pending regulations by EPA on the use of transgenic methods to create plants that resist pests has placed another constraint on pest management. Purdue 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), and non-pesticide alternatives to manage stored grain quality.

The challenge of ensuring the health and well being of animals, while maintaining maximum production remains important to Indiana producers. Purdue is working to ensure that livestock are raised under conditions that minimize diseases and stress, maximize productivity, reduce environmental pollution, and are acceptable to consumers. Researchers are working to eliminate gastric ulcers and bleeding disorders in pigs, developing new

DNA vaccines for chickens, determining dietary needs of fish, and finding ways to improve the well being of swine while making them more productive.

U.S. agriculture must compete in a dynamic global economy. Major contributors to the globally competitive position of U.S. agriculture include the development of new technology innovation, changes in business structure, information systems, and modern transportation and marketing systems.

Consolidations and mergers have become regular occurrences. Evolution of businesses 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. Rapid communication systems, transportation cost reductions, and the speed at which capital can be transferred around the globe are the driving forces behind a globally competitive system. Studies have been conducted and information distributed that relate to and have impact on state and federal policy as well as the evaluation of different tactics and strategies for producer and business enterprises in this emerging global economy.

By enhancing the value and utility of agricultural, horticultural, and forest products, Purdue is providing Indiana farmers and businesses with opportunities to compete in new markets and obtain greater economic benefits. At the same time, many of the value-added products being developed have environmental or nutritional benefits that, over the long run, will have a positive impact of the quality of life for all. Purdue research in this area seeks to create new uses for agricultural producers, 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. Programs are also addressing ways to use carbohydrates and oils to make industrial products, such as substitutes for petroleum-based plastic or enhancing the nutritional quality of grains for livestock and people. Other researchers are looking for new uses of agricultural products and by-products as feed for livestock and fish.

Successes:

- Estimated that modest growth in livestock productivity in China will offer opportunities for an increase in U.S. meat exports
- Determined that ractopamine use in swine reduces nitrogen and phosphorus in manure output
- Estimated that pork processors have more market power in the wholesale than in the live hog market
- Determined that under minimum tillage systems a 1.0 or 0.5 hectare soil sampling grid may be too sparse to accurately assess potassium availability
- Found that melon producers in Southwest Indiana should consider black mulch and Furadan to control the striped cucumber beetle and bacterial wilt
- Developed a zebrafish genetic model to test the transfer of embryonic cells into a host embryo
- Created more than 300,000 genetically-altered Arabidopsis plants as a first step to identify gene function

- Located the genes responsible for aggressive behavior in Africanized bees
- Found a way to exploit genetic diversity to stop genetic mutations that led to pesticide resistance
- Identified genes responsible for rice blast disease
- Discovered the mutant gene in Arabidopsis responsible for salt tolerance
- Found that the antibiotics lincomycin and neomycin reduce the severity of gastric lesions in swine
- Developed a DNA vaccine that can protect chickens from infectious bursal disease virus
- Determined the dietary requirement for sulfur amino acids in economically important fish species
- Developed an assay to help determine the cause of porcine hemorrhagic syndrome
- Identified genes that determine aggressive behavior in swine and poultry
- Found that expression of a gene in chicken stimulates muscle development *in vivo* by threefold and may be useful for increasing poultry production
- Developed a method for treating septic arthritis in horses using continuous intracellular infusion of antibiotics
- Identified several probiotics and prebiotics that show promise as alternatives to sub-therapeutic levels of antibiotics in livestock
- Determined that an areawide approach to corn rootworm control would only be cost effective with successful suppression of the adult female beetles with a semiochemical, aerially applied bait
- Developed a microprocessor computer board to control the fan and heater on a grain dryer that results in a consistently higher quality stored corn
- Found that a microbial protease increased the activity of plasminogen activators which enhanced the rate of cheese ripening
- Developed gelatin dessert substitutes and candles from soybeans
- Developed protein coatings to serve as blocking agents on biochips

Benefits:

- U.S. livestock producers will enjoy increased meat exports given the expected rapid demand growth in China coupled with modest productivity growth in China's livestock sector
- The use of ractopamine in hog rations can reduce soil and water contamination from hog manure, while still enhancing the quality of pork production
- Pork producers should be cautious about investing in slaughter facilities given the market power of existing packers
- More accurate potassium soil testing will optimize farmers' returns on fertilizer investments
- Alternative fumigants and mulch systems can help Indiana melon growers replace methyl bromide fumigation
- Identification of the gene responsible for the aggressive behavior of Africanized bees will help in the selection and breeding of more 'gentle' bees for pollination of U.S. crops
- Understanding the causes of rice blast fungus will lead to the development of new fungicides
- Strategies for improving crops salt tolerance can be developed through biotechnology and breeding
- Methods for fighting gastric ulcers in swine will improve production efficiencies and minimizing losses
- A DNA vaccine for infectious bursal virus will minimize economic losses from variant strains of the disease
- Identification of the causative agent for porcine hemorrhagic syndrome will allow producers to avoid feeds containing the agent and eliminate the need to supplement swine diets with vitamin K, reducing feed costs
- Indiana farmers are likely to be early adopters of transgenic corn to control corn rootworms
- A microprocessor board on a fan and heater assembly can help farmers dry corn more uniformly and enhance stored grain quality
- Reduced ripening time for cheese can have large economic benefits to cheese manufacturers
- Candles and candle waxes developed from soybeans are currently being commercially produced and sold
- Bioseparation engineering is contributing to the development of biochips to detect targeted organisms for food safety and pathogen identification

State Assessment of Accomplishments:

The research program has clearly addressed the needs of producers and the concerns of the public. This research has spanned a broad base, for example, developing animal diets to reduce impacts from waste; evaluating new technologies as tools for agricultural competitiveness; evaluating contractual and structural options for producer competitive positioning; and developing the base for value added products that have the potential benefit for the consumer and producer.

Resources:

Approximately \$9,481,870 and 74 FTE have been invested in Goal 1. This is a best estimate and these are not presented as auditable numbers.

1. A. Integrated and Sustainable Crop and Livestock Production Systems

Key Theme: Agricultural Competitiveness

- a. *Description:* Rapid income growth in the developing countries, coupled with a dietary transition in which many of these households are adding more meat in their meals, ensures a strong surge in the global demand for meat in the coming two decades. How much of this will be supplied locally, and how much will be supplied via exports from the United States and elsewhere? The answer to this question depends heavily on productivity growth in the livestock sectors of the developing countries. For example, after controlling for other livestock production inputs in China, a simulation model analysis suggests that livestock productivity has been very flat -even decreasing, and future productivity growth will be modest. This has significant implications for future Chinese import demand for meat products.
- b. *Impact:* U.S. meat producers face a difficult problem in gauging the potential offered by China's market in the coming decade. Previous studies may have significantly over-stated productivity growth in China's livestock sector by focusing on simple measures of output per head. By taking into account other livestock production inputs, this study finds that future productivity growth is likely to be more modest - thereby opening the way for increased Chinese meat imports. This may offer an opportunity for U.S. meat producers to increase exports to China.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Agricultural Profitability

- a. *Description:* Some pork producers are interested in the financial feasibility of the cooperative ownership of a modest-sized slaughter plant. Since the financial stress in the pork industry in 1998, there has been great interest in alternative ways of adding value to hogs. Previous analysis used a traditional Net Present Value (NPV) approach to analyze this type of investment. Given the uncertainties in the live hog and wholesale pork markets such an approach is not valid. To properly analyze this investment, a Real Options approach is more appropriate. This research quantified the input and output price uncertainties that a cooperatively owned slaughter plant would face. Pork slaughter is a very concentrated industry and existing firms might employ predatory pricing to drive a farmer-owned cooperative out of business. Econometric analysis of the meat sector suggests that pork packers have significant market power in the wholesale pork market, but not in the live hog market. Market power increases with capacity constraints and unanticipated demand shocks.
- b. *Impact:* Pork producers should be cautious about making large irreversible investments in slaughter facilities. This work shows that existing packers have the capability to employ short-term predatory pricing behavior to force a farmer-owned cooperative out of the market.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key theme: Animal Production Efficiency

- a. *Description:* Twenty-four Dekalb crossbred barrows housed in metabolism stalls were used to determine the effect of crude protein level and ractopamine on nutrient excretion and odors in anaerobically stored manure. Pigs were randomly assigned to one of four diets. Feces and non-acidified urine were collected twice daily for three consecutive days. Air samples were collected and used for an olfactometry analysis. Ractopamine improved N utilization, decreased N excretion, tended to decrease manure output, improved P utilization with minimal changes in P excretion, and helped reduce odor emission in stored manure.
- b. *Impact:* Inclusion of ractopamine in pig diets improved gains and feed efficiency by 21 to 22%, reduced manure production by 7 to 9%, and reduced total nitrogen excretion by 30 to 36%. In addition, odors were reduced 50% with the inclusion of ractopamine in the diet. The use of ractopamine enhances quality pork production, while reducing the threat of nitrogen overloading of soils, contamination of water, and odor emission from pork production operations.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key theme: Plant Production Efficiency

- a. *Description:* In Indiana, there are over 400 soil types in 13 major soil groups that range from sands to clayey glacial till. Corn and soybean response to recommended potassium fertilizer rates are highly variable across major soil groups. Five long-term field sites were established in 1997 at locations representative of different major agronomic soils of the humid region of the Eastern Corn Belt. Soil test data were analyzed to determine optimal yields and grain quality. Minimum tillage practices do not significantly mix the top 0.2 meters of soil. Potassium stratification was pronounced at all sites and, in drier years, recommended soil concentrations for bulk samples of the plow layer (0.2 meters) were required below the surface (0.1 to 0.2 meters) to meet plant potassium demand, suggesting that subsurface soil may need to be assessed separately so that test values are not skewed by high, but unavailable surface soil concentrations. Also composite soil samples collected at centers of 1 or 0.5 hectare grids were too spatially sparse to assess within field variability in soil test potassium. While grain potassium concentration varied substantially with potassium fertility, potassium removal in grain was highly correlated with corn and soybean yields. Continuous yield data from combine-mounted monitors created relatively accurate nutrient removal maps for fields with pronounced spatial variability in soil test potassium.
- b. *Impact:* Over 70% of Indiana agricultural soils are inherently potassium deficient. Furthermore, large within-field variability in soil potassium supply typically exists, and appropriate soil sampling strategies that accurately characterize this spatial variability can be a major investment. Potassium is a multi-tasking essential nutrient element that helps plants withstand stresses from drought, cool soils, and soil compaction; resist diseases; and achieve high quality yields. Accurate soil potassium test information and efficient collection strategies are essential to optimizing returns on fertilizer investment. Purdue researchers have created a database that will improve potassium management recommendations for corn/soybean rotations in the Eastern Corn Belt.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key theme: Plant Production Efficiency

- a. *Description:* Muskmelon and cantaloupe production in Southwestern Indiana has recently experienced significant insect and disease problems. Field studies were conducted at Southwest Purdue Agricultural Center in Vincennes, Indiana during 2001 to compare alternative management practices for striped cucumber beetle control. Three mulch and nine chemical treatment combinations were analyzed. There were significantly more striped cucumber beetles where mulch was used than on bare ground, but no significant differences among chemical treatments. There were highly significant differences in bacterial wilt percentage among the three mulch treatments and chemical treatments. The highest percentages of bacterial wilt among mulch and chemical treatments were the clear mulch and methyl bromide + Furadan, respectively. The lowest percentages were the

no mulch and Furadan treatments. Among the three mulches, the lowest percentage of bacterial wilt occurred in the black plastic mulch plots. The highest yield among mulch and chemical treatments were black mulch and Furadan, respectively, whereas the lowest yields were the no mulch treatment and methyl bromide with Furadan, respectively. There was a highly significant difference in yield, including number and weight of fruits, among chemical treatments, but no significant difference among mulch treatments

- b. *Impact:* The results of these studies will help Indiana melon growers select both mulch and chemical treatments that will reduce damage from striped cucumber beetles and bacterial wilt. This research will help growers replace methyl bromide fumigation with alternative fumigants.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

1.B. Genetic Resource Development

Key Theme: Animal Genomics

- a. *Description:* The development of models for genetic studies of development of animals is critical to the application of genomics to livestock species. The ability to assign function to genes identified through genome sequencing efforts will rely on the capacity to inactivate genes in these model species, before progressing to studies with species of agricultural significance. Although the zebrafish possesses many characteristics that make it a valuable model for genetic studies of vertebrate development, one deficiency of this model system is the absence of methods for cell-mediated gene transfer and targeted gene inactivation. Purdue scientists demonstrated transgenic zebrafish could be produced through the transfer of embryonic cells into a host embryo to create a germ-line chimera.
- b. *Impact:* These studies were the first to show that zebrafish embryo cell cultures could be used as a source of transgenic cells to produce transgenic fish when introduced into a host embryo. This work has led to the development of cell-based gene transfer techniques that are being used for targeted gene inactivation in zebrafish. This will enable scientists to test the function of genes in development and cellular processes critical to livestock productivity.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Plant Genomics

- a. *Description:* Arabidopsis has the distinction of being the first higher plant to have the complete genome sequenced. This revealed the presence of around 25,000 genes that are necessary for the

growth and development of this model species. Assigning function to these genes is critical to advancing crop productivity through breeding and biotechnology. Purdue scientists have created more than 300,000 genetically altered arabidopsis plants as a first step to identifying the function of each gene. This is accomplished by creating transgenic plants that lack a single gene, and growing these to maturity to observe the effect of the missing gene on plant development and productivity.

- b. *Impact:* The availability of genetically altered populations of arabidopsis serves as a resource to scientists around the world who seek to identify the function of genes they are studying. This work has led to the functional identification of numerous genes involved in critical processes of plant growth and development. This will expedite crop improvement through traditional breeding and biotechnology.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Invasive Species

- a. *Description:* The highly aggressive stinging behavior in Africanized honeybees – the so-called “killer bees” – is disruptive to agriculture and can be dangerous to humans. These Africanized bees are established in most of South America, Mexico and in the Southern region of the United States. The aggressive behavior of these bees has already disrupted the beekeeping industry in Mexico and promises to do the same in the United States, where one third of all food produced relies on bees for pollination. Purdue scientists, working with colleagues in Mexico, are using gene mapping techniques to locate the genes that influence behavior in Africanized bees.
- b. *Impact:* The development of specific gene markers that predict the probability of queen bees having the African version of stinging genes allows for the selection and breeding of more “gentle” bees. This work is also impacting the vast field of neurobiology, where discoveries related to bee stinging are helping to define the biochemical basis for aggressive behavior.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Risk Assessment

- a. *Description:* For years, farmers and agribusiness have talked about being on the “pesticide treadmill”: A few years after a new pesticide is introduced, insects develop resistance, leading to the need for new chemistries. Purdue scientists believe they have found a way to exploit genetic diversity to stop, or at least slow this cycle to a crawl. This is called negative cross-resistance and relies on the nature of genetic mutations that lead to resistance to one toxic chemical, while often resulting in hyper-susceptibility to another.

- b. *Impact:* The knowledge of negative cross-resistance led Purdue scientists to develop an approach for the systematic development of toxins that serve to selectively kill resistant insects following treatment with pesticides. Treatment with both compounds effectively kills the entire insect population thus preventing the development of resistant offspring and extending the life of newly developed pesticides.
- c. *Source of Federal Funding:* Hatch
- d. *Scope of Impact:* Multistate

1.C. Plant Stress Management

Key Theme: Plant Health

- a. *Description:* Heavy metals such as nickel are often toxic to plants and animals. Soils in many parts of the world are rich in toxic heavy metals, limiting their capacity to produce crops. One approach to “mining” these heavy metals from soils is to use plants that remove the contaminants from the soil, thus remediating the pollution. Purdue scientists have identified a plant species (*Thalpi goesingese*) that is capable of growing on sites where the amount of nickel is very high. These plants were found to hyperaccumulate nickel to concentrations 10,000-fold greater than most crop plants. Genes encoding metal tolerance proteins were isolated from this species and shown to be responsible for the transportation of nickel into the plant cell vacuole, thus rendering it non-toxic to the cell.
- b. *Impact:* This work, for the first time, has revealed the cellular mechanism responsible for accumulation and sequestration of heavy metals, rendering normally toxic compounds are tolerated by plants. The transfer of these genes into plants that produce significant biomass will provide a mechanism to remove toxic heavy metals from soils. Such phytoremediation efforts will reclaim soils contaminated through mining and other industrial activities.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Plant Health

- a. *Description:* Many fungi come in contact with plants, but only a few are capable of causing disease. Identification of the factors in fungi responsible for infection and disease development is critical to the development of new fungicides. Purdue scientists have made a critical step forward in the fight to control the causal organism of rice and wheat blast. Two genes necessary for causing rice blast disease were identified and found to be responsible for colonization of the plant by the fungi.
- b. *Impact:* The discovery of two important virulence factors from the rice blast fungus will provide targets for the development of new fungicides that can be used to reduce infection and prevent the development of the rice and wheat blast diseases.

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

Key Theme: Plant Genomics

- a. *Description:* High salt levels found in one-third of the world's cropland causes reduced yields and limits the range of species that can be used of food sources. In the United States, salt toxicity in crops is also a problem in areas where irrigation is used extensively, such as on high value crops in California. A group of scientists at Purdue University have taken a genomics approach to identifying the genes in salt sensitive plants that when mutated allow them to survive this stressful environment. The *AtHKT1* gene from *Arabidopsis thaliana* was found to be responsible for sodium uptake into roots. Mutations in this gene resulted in a reduction in sodium accumulation and an increase in tolerance to salt.
- b. *Impact:* This study points the way to engineering crops to withstand higher levels of salt in the root environment. Based on the identification of the sodium uptake gene and other associated genes, strategies for improving crops salt tolerance through breeding and biotechnology can be developed and implemented.
- c. *Soucre of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Plant Health

- a. *Description:* The surface waxes on plant leaves have long been regarded as a first line of defense against invading pathogens. In addition, this layer of epicuticular wax serves to reduce the loss of water from leaves, thus conserving soil moisture. Scientists at Purdue have been looking for genes that are necessary for the synthesis of waxes in sorghum with a keen eye on identifying genetic variants that impact water loss and disease resistance. Using chemical mutagenesis of DNA, these scientists have identified a number of genetic lines that vary in the chemical composition of their leaf waxes. These studies have revealed a strong correlation to wax type of susceptibility to foliar fungal diseases.
- b. *Impact:* The identification of key steps in the biosynthesis of leaf waxes has led to a number of genetic variants of sorghum that are resistant to several fungal diseases. This work is leading to the development of plants with improved disease resistance, as well as the elucidation of how waxes are synthesized in plants. This will reduce chemical pesticide use and improve plant drought tolerance in the future.

c. *Source of federal funding:* Hatch

d. *Scope of Impact:* Multistate

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

Key Theme: Animal Health

- a. *Description:* Ulceration of the pars esophagea in pigs is a problem that affects various stages of swine production. Gastric ulcers contribute to economic losses through sudden death, compromised weight gains, decreased feed efficiency, and premature culling of breeding animals. Effectively addressing the gastric ulcer problem has been difficult due to the multifactorial nature of the disease. Purdue researchers have evaluated the effect of feeding antibiotics on the severity of gastric lesions. Pigs were pulse-fed neomycin and lincomycin, and continuously-fed lincomycin from the grower phase to market weight. Feeding antibiotics significantly reduced the severity of gastric lesions in market age pigs when compared to pigs receiving no antibiotic.
- b. *Impact:* Antibiotic feeding reduces the severity of gastric lesions in market-age pigs. This may represent a viable method of minimizing the economic losses associated with gastric ulcers in pigs.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

1.E. Farm Business Management, Economics, and Marketing

Key Theme: Agricultural Profitability

FY '01 Focus: Improved Pest Control and Food Quality and Protection Act Implementation

- a. *Description:* Many U.S. farmers incur large expenditures on soil insecticides to control corn rootworms. Research on an alternative control method, areawide pest management, is being conducted by the United States Department of Agriculture-Agricultural Research Service, in cooperation with several Mid-Western Land Grant Universities. Based on crop scouting information, a semio-chemical bait is aerially-applied during the growing season to suppress the adult female beetles before eggs are laid. Costs are higher initially, but are expected to decline in subsequent years if beetle suppression is successful and soil insecticide use can be eliminated. Using a Net Present Value (NPV) approach for an eight-year planning period, an economic study found that areawide pest management is not as profitable as soil insecticides for the USDA-ARS experimental sites in Indiana/Illinois or Iowa, but compares favorably in the Kansas site. Also regression techniques were used to estimate yield benefits from soil insecticide use, based on university test-plot data from Indiana, Iowa, and Kansas for the years 1990-1999. In Indiana and Iowa, soil insecticide use was generally profitable. Under irrigated conditions, soil insecticides were not profitable in Kansas.
- b. *Impact:* Areawide pest management for corn rootworm control so far does not appear to be economically viable for corn growers in the Eastern Corn Belt where there is increasing pressure

from the Western corn rootworm variant. Farmers in this region will likely either continue to use soil insecticides and/or be earlier adopters of transgenic corn with corn rootworm resistance once it is commercially available.

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

Key theme: Managing Change in Agriculture

- a. *Description:* The structure of business organizations can affect profitability. The risk and return implications for beef producer investments in value-added agribusinesses were estimated with simulation models. The simulation model incorporated the stochastic nature of prices along with appropriate correlations among different price series. Results suggest that producers will gain from diversifying their operations beyond the farm level, maintaining a balanced financial portfolio, and leveraging their investment into more profitable businesses. A two part approach was employed to examine the driving forces and success factors for agribusiness reorganization. A conceptual model was developed, followed by a case study of the merger between Cenex and Harvest States Cooperatives. This business reorganization was based on the external forces of changing demand, increasing competition, and advancing technology, plus the internal forces of company goals and objectives, resources, communication, commitment and trust. Factors that contributed to the success of the merger were commitment, trust, communication, homogeneity of parties, and a unified vision of why the merger should happen.
- b. *Impact:* Cooperatives represent a significant portion of the agribusiness activity in the United States with over 4,300 businesses representing over four million member producers. With changes in the structure of agriculture, producers must consider new business organizational structures, including a cooperative form of organization, as vehicle to reduce economic risk and enter into value-added processing.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

1.F. Value-Added

Key Theme: Adding Value to New and Old Agricultural Products

- a. *Description:* During the last few years many natural air/low temperature grain drying strategies have been evaluated using the Purdue University Post Harvest Aeration & Storage Simulation Tool. This simulates a wide range of locations representing different weather conditions. A new variable heat fan and heater control strategy generally was ranked first based on drying costs, dry matter loss, and shrink compared to the target moisture content. This new strategy has been implemented on two 2,500 bushel pilot bins at the Purdue University Post Harvest Education and Research Center facility located near West Lafayette, Indiana. The variable heat system controls the fan and heater operation through a microprocessor board on the fan and heater assembly. Data collected during the 2000 fall

with the variable heat system show that the grain reached the final average target moisture content of 15% resulting in a small final grain moisture gradient, and without over-drying of the bottom layers (14.7%) and under-drying of the top layers (15.4%), a gradient of 0.7% points. In comparison, a second bin dried continuously with natural air reaching a final average moisture content of 13.8% and ranging in moisture content from 12.9% at the bottom to 15.3% at the top, a gradient of 2.4% points.

- b. *Impact:* This research modeled a microprocessor board on a fan and heater assembly to more uniformly dry corn and enhance stored grain quality. This is especially important for producers of specialty corn varieties.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Adding Value to New and Old Agricultural Products

- a. *Description:* The native milk enzyme plasmin, which is a protease that breaks down the milk protein casein, has been shown to reduce the time needed to ripen cheese. Plasmin exists predominantly in fresh milk in its inactive form, plasminogen, which gets converted to active plasmin by other native milk enzymes called plasminogen activators. Previous work has shown that the plasmin enzyme system may be affected by heat-stable proteases that are produced by cold-loving microorganisms that grow in milk prior to pasteurization. The effects of these microbial proteases on the plasmin system under cheese making conditions have been unknown. Microbial protease, calcium chloride, and pH each have a significant effect on both plasmin and plasminogen activity under specific conditions. The most consistent effect was increased levels of plasmin and plasminogen activity in the cheese curd with microbial protease treatment. With these results, a follow-up study was conducted to determine the effect of the microbial protease on the activity of commercial bovine plasminogen activators. The microbial protease increased the activity of one type of plasminogen activators by over three-fold and another type by 55% , which can enhance affect the rate of cheese ripening.
- b. *Impact:* Reduced ripening time for cheese can have enormous economic benefits for cheese manufacturers. Microbial protease can increase the activity of plasminogen activators, reduce ripening time, and reduce production costs.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Adding Value to New and Old Agricultural Products

- a. *Description:* The development of novel starch products depends on the ability to modify starch chemically. The focus of this research is to develop modified starch products with novel or improved properties using already approved reagents. The approach is to determine the anatomies

of granules from different sources, to determine how granule structure impacts modification, and to determine how different reaction conditions affect patterns of reaction so that new products can be made by changing reaction conditions. Using compositional backscattered electron imaging, it was determined that phosphoryl chloride reacted to a large extent at granule surfaces, while an analog of propylene oxide diffused into the granule matrix prior to reacting. The distribution of substituent groups between amylose and amylopectin molecules of hydroxypropylated corn starch products, prepared under different reaction conditions, was determined. Purdue researchers found that 1.8 times the amount of propylene oxide was needed to get the same molar substitution when potassium citrate was used as compared to sodium sulfate. It was demonstrated that channels and cavities are natural features of corn starch granules, that channels are present in very early stages of kernel and granule development, and that when granules are placed in water, cavities swell somewhat closed, while channels remain open.

- b. *Impact:* Most starch used in food and industrial products is modified to improve its usefulness. Because of restrictions on reagents that can be used and levels of substitution, the only way to produce starch products with improved or novel properties is through a more thorough understanding of the nature of starch granules and the relationship between granule structure and behavior. Knowledge gained from this project provides another step in the development of strategies to control and/or to modify the sites of reaction in starch granules to produce novel or improved foods.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Biobased Products

FY '01 Focus: Biobased Products Program

- a. *Description:* Lipids and sugars are major sources of energy and raw materials for industrial products and applications. With dwindling petrochemical supplies, these raw materials must be developed into products to replace current petrochemical products. Research on biosurfactants has developed a novel product made from maltose and long-chain fatty acids from vegetable lipids. This surfactant has a surface activity nearly 1000 times more effective than sodium lauryl sulfate, the most commonly used detergent/soap component, which is derived from petroleum components. Research on candles has developed several candle compositions which eliminate petrochemically-based paraffins. Industrial partners are now commercializing this technology. Research on soybean proteins, in combination with carbohydrate gels, has led to the development of gelatin dessert substitutes. By eliminating animal gelatin proteins, issues involving animal derived products have been eliminated, as well as enhancing nutritional benefits by incorporating soybean isoflavones in the product. This composition is currently in pilot plant industrial testing at a commercial partner facility.
- b. *Impact:* This project has had significant impact beyond scientific knowledge and publications. Several of the products have commercial applications. Products based on these technologies are in various stages of final development or commercialization by industrial partners. The Alltrista

Corporation has developed and is selling both candles and candle waxes based on technologies developed in this project.

c. *Sources of Federal Funds:* Hatch

a. *Scope of Impact:* Multistate

Key Theme: Biotechnology

a. *Description:* Biochips that combine concepts from biology and electrical engineering can have wide applications in crop production, storage, and food processing. Non-specific adsorption causes the selectivity of a stationary phase to be compromised since molecules other than the target protein adsorb. Upon desorption, a mixture of the target protein, together with undesired molecules (contaminants), results. This presents a significant challenge in designing biochips (i.e., computer chips with microfluidics channels to which bioreceptors are attached to capture target molecules or organisms). Research on bioseparation engineering can minimize non-specific adsorption of proteins or organisms on silica surfaces of biochips by chemically derivatizing the surfaces with a layer of polymer. This polymer is in turn coated with a protein or a second hydrophilic polymer that blocks the adsorption of components found in a sample that might be presented to the chip. When a bioreceptor, such as an antibody, is attached to the coating, the bioreceptor will specifically capture the target while adsorption of non-target species on the surface will be minimal. Validation of the effectiveness of this approach is being provided through plasmon resonance spectroscopy, fluorescence microscopy, and tests using various types of labeled proteins and microorganisms. The results show that some types of protein coatings are effective as blocking agents, and that non-specific binding of organisms is significantly less compared to surfaces that are not coated.

b. *Impact:* Fundamental research in bioseparation engineering has yielded techniques and knowledge that will be useful for developing miniaturized chips for detecting a range of target organisms and molecules. A cross-disciplinary team in the Schools of Agriculture, Engineering, and Science, has placed proteins on chips that effectively block innocuous organisms and form a platform for attaching bioreceptors placed on the chip to capture pathogenic organisms. This development is contributing towards the assembly of biochips that will be able to rapidly detect targeted organisms and will find application in food safety, identification of pathogens, and discovery of new types of therapeutic proteins.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Multistate

GOAL 2: SAFE AND SECURE FOOD AND FIBER SYSTEM

Overview: Food safety continues to be a priority for consumers, food producers, regulators, and scientists. Even though the U.S. food supply is among the world's safest, the Center for Disease Control estimates that

approximately 76 million illnesses and 5,000 deaths are caused each year by foodborne diseases. Following the recent terrorism attacks on our Nation, we are faced with new challenges to ensure the safety and quality of our food supply. Better food safety methods are needed not only for accidental contamination during food production and processing, but also for intentional infection with biological or chemical terrorism agents.

Purdue researchers continue to make strides in developing advanced methods for detection and destruction of infections agents and toxins in our food. Through a partnership with USDA-ARS, the Center for Food Safety Engineering is developing advanced engineering-based solutions to many food safety problems. Methods for more rapid and effective detection of *Fusarium*, *Listeria*, polychlorinated biphenyls (PCBs), and *E. coli* are being investigated by many Center scientists. Others are working on better ways to destroy pathogens in both fresh and processed foods.

Food safety and security is not only about detection and destruction of pathogens in food, but also the prevention of exposing livestock and crops to potential hazards before they are processed or prepared for distribution. Purdue scientists are looking for ways to reduce pesticide residues on fruits and vegetables, while maintaining productivity. In the wake of the foot-and-mouth disease crisis in Great Britain, the importance of containing disease outbreaks that threaten our food supply has received much attention. Purdue researchers are looking for ways to prevent the spread of emerging diseases in crops and livestock.

Successes:

- Developed a rapid and specific method for detecting mycotoxin-producing *Fusarium* species in grain
- Designed a system that sterilizes ready-to-eat meat after it has been packaged
- Devised alternative methods for cultivation of apples that reduces the dependence on organophosphate pesticides
- Developed a rapid and specific method for detecting small quantities of *Listeria monocytogenes* in food
- Determined a more effective procedure for using boot baths in preventing the spread of animal diseases

Benefits:

- Rapid methods to detect food contaminants like *Fusarium* mold and *Listeria* will protect human health and prevent economic losses by producers and processors
- Sterilizing food after packaging will prevent the introduction of pathogens into the food supply, ensuing consumer confidence in food safety and preventing death and illness
- Proper sterilization of boots and shoes before contact with animal lots will help prevent the spread of potentially devastating animal diseases, whether they are naturally occurring or introduced through bioterrorism

State Assessment of Accomplishments: Purdue researchers continue to address the food safety concerns of Indiana's animal processing and fruit/vegetable production industries. While many direct products of this research address industry needs, the information gained from this work will also have direct benefit to consumers. The control and detection strategies developed at Purdue will reduce the risks of foodborne illness for consumers while minimizing the need for costly recalls by food suppliers.

Resources: Approximately \$543,967 and 5 FTEs were invested in Goal 2. This is a best estimate and these are not presented as auditable numbers.

Key Theme: Food Safety

FY '01 Focus Area: Improved Pest Control and FQPA Implementation

- b. *Description:* Congress unanimously passed the Food Quality Protection Act (FQPA) in 1995, which required the EPA to reconsider the registration of many pesticides, with special emphasis on the potential effects of the pesticides on children. Apples were identified as the food crop that could result in the most pesticide exposure to children and the organophosphate insecticides were the first group of pesticides that the EPA would evaluate under FQPA. As a result, apple growers have completely lost the use of some insecticides, and recent EPA decisions are likely to severely reduce the use of azinphosmethyl, the most widely used insecticide by Indiana apple growers. A Purdue researcher has evaluated alternatives to organophosphate insecticides. He tested a number of techniques, including biological insecticides, insect growth regulators, relatively soft pesticides, natural products such as kaolin, attract-and-kill technologies, and several cultural practices.
- c. *Impact:* The research has shown that no one technique will replace the broad-spectrum organophosphate insecticides, but that a combination of tactics will be required to successfully produce apples. Study results have been incorporated into an extension effort to provide growers with an insect control program that includes no or limited use of organophosphate insecticides. This integrated program will allow Indiana apple growers to remain competitive while transitioning away from organophosphate insecticides to methods which are better for the environment and produce safer food.
- d. *Source of Funding:* Hatch
- e. *Scope of Impact:* Indiana

Key Theme: Food Safety

- f. *Description:* Some molds, such as *Fusarium*, produce mycotoxins in grains and foods and these mycotoxins can affect the health of animals and humans. The ability to detect these molds in grains and foods before they can produce mycotoxins is critical to protect human health and prevent economic losses by producers and processors. A Purdue researcher has isolated and characterized antibodies to *Fusarium* molds that commonly contaminate grains in the Midwest. She used the antibodies to develop a rapid immunoassay method to detect molds in food.
- g. *Impact:* This researcher has shown that a rapid method can be developed to specifically detect *Fusarium* species. This new method takes less than 2 hours to detect these molds compared to 3 to 5

days for more traditional methods. A licensing agreement has been signed with a diagnostic company to produce rapid test kits for mold detection based on this research. Soon, food companies will be able to detect mold contamination using commercially available tests and prevent introduction of these foods into the marketplace.

- h. *Source of funds*: Hatch
- i. *Scope of Impact*: Multistate

Key Theme: Food Safety

- a. *Description:* Chlorine dioxide has been investigated as a potential non-thermal treatment for inactivation of pathogens in fruit and vegetables. Pathogen contamination in the past decade has been an increasing concern for consumers and the food processing industry. The objective of this project was to evaluate the reduction of *Listeria monocytogenes* on green pepper surfaces after exposure to various chlorine dioxide gas treatments. Chlorine dioxide gas treatment was the most effective in reducing *Listeria monocytogenes* on both uninjured and injured green pepper surfaces, when compared with chlorine dioxide aqueous treatment and water washing.
- b. *Impact:* The use of chlorine dioxide gas treatments was successful in reducing *Listeria monocytogenes* on green pepper surfaces. This technique offers a new processing alternative for the fruit and vegetable industry.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Food Security

- j. *Description:* Purdue researchers are identifying the biosecurity procedures needed to prevent mechanical transmission of porcine pathogens. They have studied the use of boot baths to prevent the transfer of pathogens among groups of pigs. The efficacy of several disinfectants and boot cleansing methods was investigated. This study found that walking through the boot bath alone, regardless of disinfectant used, did not disinfect boots. Researchers noted that, except when using the most expensive of the disinfectants, standing in the bath for 2 minutes also did not significantly reduce bacterial counts.
- k. *Impact:* Only the physical removal of manure from boots by scrubbing them prior to a boot bath was effective at disinfecting boots. Researchers found that improper use of boot baths may place pigs at risk for infection. This information will ensure the efficacy of boot baths where prior removal of manure is feasible.
- l. *Source of funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Foodborne Pathogen protection

- m. *Description:* *Listeria monocytogenes* is a deadly foodborne pathogen that causes about 500 deaths annually in the United States. Researchers are developing biosensor-based technologies that would sensitively detect and identify *L. monocytogenes*, to prevent economic losses, outbreaks and related illnesses. Immunobeads were used to capture *Listeria* cells from naturally contaminated or spiked hotdog samples after a selective enrichment step, and bead-captured bacterial cells were directly

tested in a cytotoxicity assay. Results showed that *L. monocytogenes* at a concentration of about 1-100 CFU/100 ml of food extract could be captured in 12-18 hours after sampling and subsequently be detected in an additional 1-2 hours. Advantages of this current assay include its specificity for *L. monocytogenes*, detection of only viable cells, detection of virulent *Listeria*, and relatively speedy detection.

- n. *Impact: Listeria monocytogenes* can be fatal (estimated 20% fatality rate), even when very small numbers of cells are ingested. Purdue researchers have developed a sensitive and rapid two-step method to detect this deadly organism at concentrations less than 1 CFU/ml of food extract in 14-20 hours. This improved sensitive method would reduce time for overall *Listeria* analysis of ready-to-eat food products. Packages of contaminated food could be pulled out of distribution before reaching the consumer, thus saving lives and reducing economic losses.
- o. *Source of funds:* Hatch
- p. *Scope of Impact:* Multistate

GOAL 3. A HEALTHY, WELL NOURISHED POPULATION

Overview: 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. There is increasing evidence that diet is one of the most significant factors influencing the health of individuals. In order to ensure continued improvements in the well-being of the public, better nutritional guidelines and new foods with improved or added benefits are needed. To that end, Purdue researchers have identified and quantified the constituents of a healthy diet, identified foods or dietary supplements that will improve deficiencies or prevent future health problems, and developed raw or processed foods with traits that add both nutrition and value. This work will lead to a healthier, better informed public capable of making smarter choices among a wide variety of nutritious and functional foods.

Purdue researchers have made great strides in developing new foods with added or improved nutritional benefits and dietary guidelines to lower the risks of developing certain health problems in humans. Nutrition specialists, food scientists, and plant biologists are working to develop better ways to manage a variety of factors that affect health. They deliver dietary guidance and programs in partnership with Purdue Extension and various state and national health organizations. They provide both a means of delivery to the public, and a pathway for identification of future research needs.

Purdue researchers have focused on both identifying and correcting deficiencies in essential nutrients such as calcium absorption and isoflavones for bone health. They have investigated the role of diet in the regulation of cholesterol and bile acid metabolism. Purdue work suggests that with protease pretreatment, sorghum digestibility can be enhanced for animal feed, and human consumption in low income countries, such as infant weaning food in Africa.

Through understanding the fundamental mechanisms that control cellular cell processes, such as division, new targets for pharmaceuticals, gene therapies, and antimicrobials can be identified. Purdue researchers have advanced the fundamental understanding of proteins and genes that could ultimately lead to the development of new drugs to treat a variety of diseases including AIDS and cancer. They have identified several important regulatory enzymes that can be targets for treatment of nervous, cardiovascular or endocrine

disorders. Other work has identified biochemical pathways in bacteria that can be used in the development of new antibiotics.

Successes:

- Studied the effect of soy protein and isoflavones on calcium metabolism and bone health in rats
- Found that with protease treatment high protein digestibility of mutant lines of sorghum showed higher starch digestibility similar to rice and maize
- Developed a method to identify hairpin loop secondary structures in DNA and RNA that possess unusual thermodynamic stability

Benefits:

- Substitution of animal protein with soy protein in diets can reduce bone loss
- Increasing the digestibility of sorghum can bring nutritional value to consumers in developing countries, especially infant weaning food
- Accurate prediction of RNA secondary structure in living cells can improve the changes for developing antisense drugs to treat AIDS and cancer

State Assessment of Accomplishments:

Research under this goal is addressing Indiana's needs in terms of improving the health and well being of the citizens in the state. Research has clearly demonstrated approaches to reducing the risk of cancer, lowering the chance of osteoporosis and in general, improving the overall well being of the citizens of Indiana. Citizens are provided information regarding potential health impact of their food choices.

Resources:

Approximately \$522,504 and 5 FTEs have been invested in Goal 3. This is a best estimate and these are not presented as auditable numbers.

Key Theme: Health Care

FY '01 Focus Area: Scientific Basis for Optimal Health

- a. *Description:* The effect of soy protein and soy isoflavones on calcium metabolism and bone health was studied in an ovariectomized rat model and in postmenopausal women. Both studies used metabolic balance and isotopic tracer techniques to determine calcium kinetics. In the rat study, histology was also used to determine bone turnover and phytoestrogens were directly compared to

estrogen. Results show that milk protein-based diets result in hypercalciuria compared to soy protein-based diets.

- b. *Impact:* Estrogen replacement therapy is recommended for postmenopausal women to reduce bone loss. However, compliance is only 10-20%. Phytoestrogens are being used as an alternative to estrogen replacement therapy with inadequate data on their efficacy. The substitution of soy protein for milk protein was shown to reduce calcium loss in urine in both rats and postmenopausal women. Isoflavones had no further advantage. Soy phytoestrogens were not able to reduce bone loss similar to estrogen replacement therapy, but substitution of animal protein with soy protein could reduce bone loss.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Human Health

- a. *Description:* Research was conducted on a highly digestible protein mutant of sorghum, concentrating on incorporation of a vitreous, hard kernel endosperm trait into the original floury mutant. Previous studies by Purdue scientists have shown that highly digestible protein in the mutant is caused by altered protein body morphology resulting in easy access of the alpha-kafirin storage protein to proteases. A rapid, relatively high throughput screening assay was also developed. Purdue and Indian sorghum breeders collaborated to show that a mutation can coexist with normal-appearing kernels with fill of vitreous endosperm to their periphery (as evidenced by transmission electron micrographs of protein body structure). However, incorporation of the hard endosperm trait was not consistent among all seeds in the panicle. Further breeding work is required. In a related study, the comparably low starch digestibility of cooked sorghum flours was demonstrated to be clearly linked to its low protein digestibility. Without protease pretreatment, digestibility of starches from sorghum genotypes were consistently lower than those of maize or rice. With protease pretreatment, high protein digestibility mutant lines showed substantially higher starch digestibility and were similar to maize and rice digestibility, while normal sorghum genotypes remained poorly digested.
- b. *Impact:* Improving protein and starch digestibility of sorghum grain has the potential of making sorghum a more competitive feed crop in the United States, and an improved grain would be more nutritionally valuable for consumers in developing countries, especially as an infant weaning food. Fundamental knowledge of starch granular and molecular structure, and interactions with protein, could lead to the identification or development of genotypes for specific and new uses, and could result in methods to reduce variability in cereal processing quality.
- c. *Source of Federal Funds:* Hatch
- c. *Scope of Impact:* Multistate

Key Theme: Human Health

- a. *Description:* To understand the role of diet in regulation of cholesterol and bile acid metabolism Purdue researchers examined the role of conjugated linoleic acid. Conjugated linoleic acid 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 semi-purified diet with either butter or corn oil supplying the lipid (4%) and 0.25% cholesterol added. Control butter was compared with butter naturally high in conjugated linoleic acid, butter with 0.16% commercial conjugated linoleic acid, butter with 1% commercial conjugated linoleic acid, corn oil control, corn oil with 0.16% conjugated linoleic acid, and corn oil with 1% conjugated linoleic acid. After 4 weeks of feeding, serum and liver cholesterol, hepatic abundance of cholesterol, and bile acid excretion were measured. With butter as a source of lipid there was little change in serum or liver cholesterol levels. Serum cholesterol was not changed with corn oil as a lipid source, but there was a significant increase in liver cholesterol level (almost 3-fold) with the highest intake of conjugated linoleic acid.
- b. *Impact:* Increased understanding of the mechanisms by which dietary components regulate cholesterol balance will make it possible to prevent those risk factors associated with some chronic diseases.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Human Health

FY '01 Focus Area: Scientific Basis for Optimal Health

- a. *Description:* Nervous conduction, muscle contraction and hormone release by endocrine cells is controlled by ion channels in cell membranes. Learning how ion channels are regulated can help us understand how nerves and muscle function normally and in disease and injury. Purdue researchers studied the biochemical steps in cells triggered by neurotransmitters and hormones that alter ion channel function. They have identified nervous signals and protein phosphatase enzymes that alter the state of phosphorylation of sodium channels in the brain and have identified a new enzyme, protein phosphatase 5, that is responsible for hormonal regulation of one form of potassium channel in endocrine cells. In addition, they have shown that nervous regulation of a specific cardiac potassium channel also requires a protein phosphatase.
- b. *Impact:* The results of these studies contribute significantly to our understanding of how cellular excitation is controlled. The regulatory enzymes Purdue researchers have identified may be new drug targets for controlling ion channel function in the treatment of nervous, cardiovascular or endocrine disorders.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Human Health

- a. *Description:* Gram-positive cocci are frequently the cause of bacterial endocarditis, a potentially life threatening infection of the heart, as well as other types of human infections. Purdue researchers are looking for biochemical pathways in these bacteria that can be used as targets of attack for the development of new antibiotics. A good target pathway should involve enzymes that confer pathogenicity or survival of bacteria and are significantly different from enzymes found in humans. Researchers have investigated the mevalonate pathway for isopentenyl diphosphate biosynthesis as one possible target.
- b. *Impact:* Results of this work have shown that the pathogenicity of Gram-positive cocci requires all six enzymes of the mevalonate pathway. The structure of the Class 2 HMG-CoA reductase (HMGR) enzyme, which mediates part of the pathway, was elucidated and found to differ significantly from those of the Class I HMGR in humans. These enzymes thus represent good targets for rational design and development of new antibiotics for treatment of bacterial endocarditis and other infections that impact human health.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Human Health

- a. *Description:* Understanding the chemical determinants of RNA folding has considerable implications for treatment of retroviral diseases. Numerous reports in the literature describe antisense RNA drug therapies for AIDS and cancer. A critical factor in designing these drugs is the choice of an accessible target sequence in the viral RNA genome. Target sequences must be relatively free of strong secondary structure in order to bind antisense agents. Unfortunately, very little is known about how RNA molecules fold into their functional three dimensional structures inside living cells. Researchers at Purdue have been studying the mechanisms that govern RNA folding during their synthesis and determining various thermodynamic and kinetic parameters that control the RNA folding process. They have developed a method to identify and isolate hairpin loop secondary structures in DNA and RNA that possess unusual thermodynamic stability (high or low). This method will yield new thermodynamic data for hairpins to be incorporated into structure prediction algorithms to improve their predictive capabilities.
- b. *Impact:* Purdue researchers have designed a new computer program that simulates RNA folding during transcription. This program and the thermodynamic stability data collected by this group will enhance our ability to accurately predict RNA secondary structure in living cells. This will measurably improve the chances for developing effective antisense drugs for the treatment of AIDS and cancer.
- c. *Source of Federal Funds:* Hatch

d. *Scope of Impact: Multistate*

GOAL 4: GREATER HARMONY BETWEEN AGRICULTURE AND THE ENVIRONMENT

Overview: Modern agriculture is dependent on the protection of our nation's environmental resources, soil, water, and air. Research at Purdue University has targeted management of natural resources at both the local and watershed scales, and this has led the improvements in water, soil and air quality. Results from this research have provided approaches, technologies, practices, and systems that enhance and sustain our resource base while maintaining the productive capacity of the land. This priority reflects the need to assist producers in meeting obligations associated with environmental quality standards such as those imposed under animal waste handling rules and the Total Maximum Daily Loads (TMDL) program. As a consequence, Purdue researchers continue to make strides in developing methods for modeling soil and water resources to allow better assessments and decisions about management of our water resources. While a reported 231 impaired streams in Indiana will need to have TMDLs, the general management principles and research associated with improvement of these waters are applicable to many locations causing a general improvement in environmental quality.

Purdue University is responding to the state's 38,000 livestock producers as they deal with Indiana's Confined Feeding Control Law. We are developing and implementing novel approaches to improve the handling of approximately 14 million tons of solid and 1.6 billion gallons of liquid manure produced by livestock. Purdue researchers also are advancing the treatment of human waste by using improved septic system designs. This is important as nearly 25% of the state's 800,000 home septic systems are malfunctioning. Implementation of novel septic systems designs for new homes is also a critical area of work because 40% of new home construction will use septic systems. However, 80% of Indiana's land area is rated as unsuitable for a typical system. We are also working to reduce the use of fungicides in the 45 million pounds of apples the state typically produces. Others are working on novel methods to reduce the use of fumigants in stored grain while still protecting the quality of approximate 816,000 bushels of corn and 269,000 bushels of soybean that are in storage. Added to this is work to use management in lieu of chemicals to control grey leaf spot and protect the recreational value of turfgrass on the hundreds of golf courses in the state.

Successes:

- Developed several decision support tools to help decision makers and community planners protect water quality
- Developed a water hydraulic system to replace the traditional oil hydraulics thereby eliminated the need to carry or handle oil
- Developed a sand filter-drip irrigation process that replaces traditional septic systems when the risk of failure is high
- Developed a method to tell if a plant is accumulating metals while phytoremediating a metal contaminated site
- Devised agroforestry systems that can provide income from livestock or crops while establishing stands of trees

- Determined that ozone fumigation is a viable alternative to pesticide fumigation for grain storage
- Developed forest management recommendations to improve the survival of neotropical migrant birds
- Devised management strategies that reduce pesticide usage on golf courses, in grain storage, and in apple production

Benefits:

- Septic system failure rates remain high and are climbing. The sand filter-drip system is an ideal method to replace these failed systems and improve the environmental quality near the homes
- The adoption of agroforestry systems in lieu of traditional row crop or livestock operations will improve the sustainability of agricultural operations while providing fewer risks to water quality
- Development of management strategies that limit the use of hazardous pesticides in grain, fruit, and turfgrass will minimize health risks from exposure to these chemicals
- Forest management strategies that ensure the survival of migratory bird species will prevent the loss of revenues from the bird-watching public in Indiana parks and forests

State Assessment of Accomplishments:

The research initiatives under this goal are addressing Indiana priorities in terms of soil, water and air quality conservation and management. Researchers have identified and evaluated technologies and tactics that can be used by producers in reducing negative environmental impacts. Producers have been provided with alternatives for manure management, replacement of pesticides, and development of buffer strips, thus lessening negative impacts on the environment.

Resources: Approximately \$1,935,008 and 18 FTEs have been invested in Goal 4. This is a best estimate and these are not presented as auditable numbers.

Key Theme: Agricultural Waste Management

FY '01 Focus Area: Water Quality

- Description:* Dietary calcium affects the liberation of phosphorus in the small intestine. Differential responses to dietary calcium concentration across differing genetic strains of broilers were noted in two preliminary experiments on the activity or efficacy of intestinal phytase. Lowering of dietary calcium appears to improve the efficacy of hydrolysis in the gastro-intestinal tract of broilers. Different phosphorus feeding programs can affect total and soluble phosphorus excretion in broilers. Broilers were fed either an industry diet, an industry diet with supplemental phytase, a diet to more closely meet the birds requirements with supplemental phytase, or a diet with low-phytate corn with supplemental phytase. Diet did not significantly affect broiler performance or bone mineralization. Industry diets resulted in the highest total phosphorus and soluble phosphorus content in litter compared with those fed low-phytate corn with supplemental phytase.

- b. *Impact:* Feeding broilers rations that more closely meet their requirements, can reduce the phosphorus in broiler litter by 31 percent, without affecting the solubility of that phosphorus. For the 45 million broilers reared in Indiana per year, this would reduce the amount of phosphorus fed by nearly 200,000 tons per year. Additional improvements in phosphorus utilization by broilers and turkeys have been noted when fungal phytase is fed in conjunction with lowered amounts of calcium and the vitamin D metabolite, 25-hydroxycholecalciferol. This work offers poultry producers with several feeding options to reduce phosphorus in litter and thus reduce potential ground and surface water pollution.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Biodiversity

- e. *Description* Many species of neotropical migrant birds, that nest in Indiana but migrate to the American tropics to winter have been declining over the last several decades. Such declines threaten the biodiversity of Indiana's natural habitats and are of great concern nationally to the 50 million people who spend \$30 billion annually enjoying birds. Currently, conservation strategies and management decisions regarding neotropical migrant birds are based on an incomplete information set, including data on only occurrence and fledging success. Purdue researchers have focused on the potential for Indiana woodlands to serve as habitats for nesting songbirds, the success of nesting adults in producing offspring, the survival of those young birds after they leave the nest (a period about which little is known), and where the surviving offspring end up breeding after their return from their tropical wintering areas. Data, including nesting success, survivorship, philopatry, and habitat selection, were collected for a suite of species. A major investigation of post-fledging survival and habitat selection for two seral woodland neotropical migrants- the gray catbird and the yellow-breasted chat- has been completed. Reasons for species declines are unclear and likely complex, but undoubtedly revolve around human activities in the environment and the resulting impacts on bird reproductive success.
- f. *Impact:* This study revealed that mortality after leaving the nest is substantial, newly independent birds seek out specific habitat structures in which to mature, and young birds tend to return to their natal regions (but not sites) to breed. These findings supply critical information with which to refine survival predictions and to define the scale at which management must occur for maximum benefit to avian populations. For example, the brushy habitats that provide young birds protection from predators and abundant food are being selected against by current forest management strategies. Management techniques that provide diversity of successional stages as well as habitat types will help to assure the continued persistence of the currently diverse woodland bird community and help retain a portion of the revenues generated by the bird-watching public.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Biological Control

FY '01 Focus: Improved Pest Control and FQPA Implementation

- a. *Description:* Fewer new chemical herbicides have been released in recent years because of environmental concerns, and escalating registration costs. Consequently, new solutions to developing weed problems are increasingly difficult to find. Researchers are developing naturally occurring fungal plant pathogens to be used as biological herbicides (bioherbicides) for the control of weeds. Bioherbicides have the potential to deliver effective, environmentally benign weed control. Purdue scientists have collected and cultured more than 200 fungi from key weeds of the Midwest, including waterhemp, giant ragweed and garlic mustard.
- b. *Impact:* This fungal collection represents a unique source of plant pathogens from weeds of the Midwest and has the potential to serve as a significant resource in the development of bioherbicides. We expect that one or more of these fungi will have significant impact as an effective and environmentally benign weed control tool for the Midwest and this will alter chemical-intensive weed management strategies presently used in no-till systems.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Integrated Pest Management

FY '01 Focus: Improved Pest Control and FQPA Implementation

- a. *Description:* Indiana apple growers regularly spray disease-preventing chemicals. Concerns for pesticide registration and environmental quality, in addition to the development of pest resistance, continue to challenge the sustainability of such chemical-spraying programs. Purdue researchers are developing minimal spray programs for control of major apple disease pests using new, more environmentally friendly, strobilurin fungicides. The minimum spray programs will allow growers to spray at the most optimum time while applying fewer sprays.
- b. *Impact:* This research provides knowledge on the optimum timing of sprays for control of major apple diseases using the new, more environmentally friendly, Strobilurin fungicides. Such minimal spray programs would have both an economic and environmental benefit as well as help delay potential resistance problems to the Strobilurin fungicides.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Integrated Pest Management

FY '01 Focus: Improved Pest Control and FQPA Implementation

- a. *Description:* Insects contaminate stored grain and cause losses of more than \$12 million annually in Indiana. In the past, grain handlers used insecticides to keep insect populations down. However, insects are developing resistance, consumers are concerned about pesticide residues, and

environmental considerations have made the production of certain pesticides illegal or too expensive. Purdue's Post Harvest Grain Quality Team has tested non-chemical methods for keeping pests out of grain including grain chilling and ozone fumigation.

- b. *Impact:* Purdue researchers looking for ways to cut use of pesticides have found a potential alternative in ozone fumigation. In initial tests, ozone fumigation killed more than 90 percent of major insect pests and cut *Aspergillus* fungus populations by more than half. Ozone leaves no residue in grain, does not escape into the environment, and appears to be economically competitive.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Land Use

- a. *Description:* Procedures for estimating changes in forest health on small-scale woodland ownerships have been perfected. Three measures of tree crown condition were examined for change over a three-year period in two Indiana state parks. The measures were crown dieback, foliage transparency and crown density. There were no significant changes in crown dieback either over or between the two parks. Additionally, low percentages of trees in the moderate and severe dieback categories suggest that the forests in the study area are not suffering from dieback stress. Foliage transparency remained unchanged for softwood species over time and between parks. While foliage transparency for hardwood species did display a change, it was well within the forest health monitoring quality objective of $\pm 10\%$. However, hickory species did indicate a rising increase in transparency, which may be indicative of increase stress. Crown density remained relatively stable over the three-year assessment period with no significant changes indicated in tree health.
- b. *Impact:* This study demonstrates that analytical techniques to summarize forest health data can provide useful land management information on small-ownership woodlands. For example, an owner interested in a particular tree species can manipulate the data to obtain the species-specific information. Further, a landowner concerned about the health of large, old growth trees can categorize forest health analyses by diameter and/or age classes. This type of information provides landowners with additional land management decision-making capabilities.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Land Use

FY '01 Focus Area: Sustainability of Agriculture and Forestry

- a. *Description:* Agroforestry systems can help solve many land use issues. These involve environmental degradation of lands and waters as well as economic productivity and diversity of farms. Purdue University has undertaken several agroforestry trials in Indiana looking at producing forages, animals, and crops under trees. Two years of field data indicate that these systems offer

production alternatives for farmers wanting to diversify or those wanting to convert marginal lands to trees. These systems also help those landowners that want to plant trees, but would like income from the land before the trees mature. Systems developed by Purdue scientists show the biological and economic potential of different combinations of plants and animals in agroforestry systems. These scientists are currently exploring some of the environmental benefits of these systems in terms of nutrient capture and recycling. Results to date show that the agroforestry treatments have lower nitrate-N concentrations in the underlying soil than control corn sites.

- c. *Impact:* Purdue scientists have developed a profitable and environmentally-friendly land management alternative that people in the state and region are beginning use. These systems provide long-term sustainability to farms, without sacrificing short-term profits while trees are established on land that previously supported only row crops or pasture. Additionally, these systems may be more environmentally-friendly than more traditional agricultural operations.

- c. *Source of Federal Funds:* Hatch

- d. *Scope of Impact:* Multistate

Key Theme: Pesticide Application

FY '01 Focus: Improved Pest Control

- a. *Description:* Outbreaks of gray leaf spot on perennial ryegrass can quickly kill large stands of turf on golf course fairways, athletic fields and residential lawns. This causes a significant loss in revenue. Because the disease is new to the Midwest, and efficient control programs have yet to be clearly defined, turf managers tend to fail to identify the problem in time to prevent serious outbreaks, apply marginally effective treatments and have limited success in keeping the disease in check, or conversely apply excess fungicide to avoid severe epidemics. Purdue research and extension efforts have resulted in research targeted towards understanding the epidemiology of the disease, investigations that will help predict outbreaks based on local weather variables, and educational programs that provide information on diagnosis and effective control options.

- b. *Impact:* Researchers found that the pathogen that causes gray leaf spot does not survive well through midwestern winters and that this influences the progress of the disease during summer months. The long lag phase of the epidemic could have important disease management implications. At Purdue's field research site, symptoms were detected in mid-July, but only after careful examination of individual leaf blades. Most turf managers would not discover infected turf until damage is clearly evident. At that time, initiation of fungicide applications for gray leaf spot control may have disappointing results. However, if turf managers applied remedial treatments at the first sign of pathogen activity rather than when outbreaks are apparent from a distance, it is probable that satisfactory control will be achieved with less fungicide.

- c. *Source of Federal Funds:* Hatch

- d. *Scope of Impact:* Multistate

Key Theme: Water Quality

FY '01 Focus Area: Water Quality

- a. *Description:* Each year non-point source pollution causes tens of billions of dollars in damage to water supplies worldwide. Due to the diffuse nature of non-point source pollution, identification of the most problematic areas in a given watershed can be difficult. While various best management practices can be used to reduce non-point source problems the need exists to identify exact areas of concern. As a result of these complexities, computer-based models are often used to quantify the magnitude of non-point source pollution at various locations and estimate the potential environmental benefits of best management practices. Faculty at Purdue have developed and made available three different decision support tools that utilize combinations of non-point source models, GIS and information technologies. These decision support tools are: -NAPRA (Pesticide and nutrient losses in runoff, sediment and to shallow groundwater) <http://danpatch.ecn.purdue.edu/~napra/> -L-

THIA (Long-Term Hydrologic Impact Assessment) <http://www.ecn.purdue.edu/runoff/> -SEDSPEC (Sediment and Erosion Control Planning, Design and SPECification Information and Guidance Tool) <http://pasture.ecn.purdue.edu/~sedspec>.

- b. *Impact:* These decision support tools are being applied in the field to assist local decision makers and community planners to identify site-specific solutions to water and environmental issues. NAPRA is being used by a water utility company in northern Indiana to develop wellhead protection plans to reduce the potential for pesticides and nitrates reaching their water supply. This has improved drinking water quality and eliminated concerns over possible contamination from agriculture. L-THIA is being used by a county Soil and Water Conservation District in central Ohio to prioritize areas for development of conservation plans. L-THIA is also being used by a regional land use planning agency in the Triangle Park area of North Carolina to assist with the creation of land use plans. SEDSPEC is being used by land use managers at Ft. Bragg, North Carolina to design methods to control erosion within watersheds. Because the models were developed for easy delivery across the World Wide Web, many others are using these tools to assist with the identification of solutions to water resources and environmental issues at local levels. These models can be applied to help a watershed achieve its TMDL goals.

- c. *Source of Federal Funds:* Hatch

- d. *Scope of Impact:* Multistate

Key Theme: Water Quality

FY '01 Focus: Water Quality

- a. *Description:* A growing demand for agricultural products has led to increased use of agrochemicals and fertilizers. The pollution of the ground water with chemicals is causing public concern, especially when approximately half of the U. S. population relies on ground water as a source for drinking water. To forestall the contamination problem caused by pesticides or other chemicals,

detection and prevention approaches are necessary. Continuous monitoring of chemicals in tile and ground water is difficult, time consuming, and expensive. Purdue researchers have developed a new modeling approach which uses finite element analysis to construct a set of models that predict the flow of water and chemicals in agricultural soils.

- b. *Impact:* This new finite element model will play a major role in predicting the movement of water and chemicals through the vadose zone into the ground water system. Accurate modeling of the transport processes will enable a rapid and relatively inexpensive prediction of groundwater contamination risk from agricultural activities. This can be used to avoid practices that pose risks to groundwater, ensuring water quality.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

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

Overview: The key to improved quality of life is enhancing the human capacity through education, developing leadership and delivery of information resource. Purdue researchers have established information resources that will aid in enhancing the quality of life for the people of Indiana. While quality of life has a different meaning depending on people's values, interests, economic status, and background, Purdue's role in researching the information and management needed by the people of the state has become critical to ensuring and maintaining strong families and business. Purdue's role in developing information resources, services, and opportunities plays a key role in the development of the state's human capacity.

The population of Indiana is changing. Between 1990 and 2000, the state's population increased 9.7% to a total of 6,080,485. Approximately 10% and 15% of the state's adults and children, respectively, live below the poverty level. Approximately 20% of the children under the age of 18 live in working-poor families and much of the state's poverty is found in rural counties. Research on the impacts of social factors on diet and health continues at Purdue. This work is needed as data show that in 1999, 40% and 24% of deaths in Indiana could be attributed to heart disease and cancer, respectfully. Over half of Indiana residents 18 and over, are considered overweight or obese based on body mass index and a disproportional fraction of overweight individuals belong to minority groups. Many of these finding are thought to reflect life-style choices that can be altered with research and education that is being provided by Purdue University.

Successes:

- ? Demonstrated that people can taste fat and this explains in part why fat-free foods are less popular
- ? Demonstrated the effects of river boat gambling on adjacent communities
- Developed *in situ* testing methods to allow the structural condition of wood floors in old buildings to be tested
- Found a way to control honeylocust pests by managing the landscape near the tree rather than simply applying pesticides
- Linked individual experience of rural families in poverty within a community context and began to describe the lives of rural, low-income women

Benefits:

- ? Pest management programs developed around landscape management and pest control result in major cost reduction, and significantly less exposure of people to pesticides

- Communities can now directly evaluate the condition of flooring in older buildings, making decisions about redevelopment of old buildings easier and more economical
- ? The demonstration of clear financial benefits derived from riverboats to the cities and communities located near them is now described and will help communities make more informed decisions
- ? Recent research on the plight of rural, low-income families is being used to ameliorate poverty in rural areas

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 researchers have demonstrated approaches to be used by communities to make better decisions about policies that affect families. Also Purdue scientists are providing producers with alternatives for debt reduction, debt restructuring, community help, planning and zoning and reduction in family stress.

Resources: Approximately \$254,940 and 3 FTEs have been invested in Goal 5. This is a best estimate and these are not presented as auditable numbers.

5. A. Improved Quality of Life

Key Theme: Children, Youth, and Families at Risk

- c. *Description:* Reducing pesticide exposure remains an important part of Purdue's efforts under this goal. For example, ornamental honeylocust trees were thought to be trouble-free; however, widespread plantings and overuse soon gave rise to three serious pest problems, honeylocust plant bug (*Diaphnocoris chlorionis*), honeylocust spider mite (*Platytetranychus multidigitalis*), and mimosa webworm (*Homadaula anisocentra*). Purdue researchers have examined the relationship of insect pest abundance to three landscape characteristics, host plant density, species diversity, and proportion of paved area around each honeylocust tree. Work has shown that arborists managing pests of honeylocust trees need to consider qualities of the landscape around each tree that can contribute to outbreaks of pest problems.
- d. *Result:* Arborists managing pests of honeylocust trees need to consider qualities of the landscape around each tree that can contribute to outbreaks of pest problems. By reducing the use of cover sprays and residual insecticides, arborists may be able to conserve communities of natural enemies in managed landscapes.
- e. *Source of Federal Funds:* Hatch
- f. *Scope of Impact:* Multistate

Key Theme: Parenting

- a. *Description* This project has explored how children's language and cognitive development is facilitated by conversations with parents at home, and teachers in preschool. One goal of this research was to address unresolved issues regarding whether or not the 'culture' of a child's home environment matches the 'culture' of their school environment, and how this match or mismatch of cultures does or does not adequately prepare young children for early schooling experiences. In this project Purdue researchers worked with preschool children, their families and teachers who were affiliated with the Head Start program in Lafayette, Indiana.
- b. *Impact:* The findings from this study have contributed to the continued development of parent education and intervention programs that work towards helping children find success in school by enhancing their early learning opportunities in the home. This study has contributed to the literature on a child's first schooling experiences, and how it impacts a child's language and conceptual development.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

5. B. Individual, Family, and Community Economic Development

Key Theme: Community Development

- a. *Description:* An economic, objective, engineering-based technique for assessing structural integrity of in-place wood floor systems in old buildings is not available. As a consequence, many old/historic structures are demolished because of the lack of technical knowledge for the safe and economic reuse of buildings. Research and outreach at Purdue are focused on combining knowledge from laboratory floor testing and field-testing of actual floors in buildings. Researchers developed a computer model that predicts the load/deflection capacity of in-place floors using the floor's natural frequency in response to vibration. The natural frequency can be determined non-invasively/non-destructively and used to predict the structural characteristics of the floor necessary for a decision on whether the floor is useable or not.
- b. *Impact:* Floor safety governs the reuse of the entire building. Many communities cite reuse of buildings, with the consequence of conservation of materials and less demand on landfills, as a major advantage in downtown redevelopment. This approach offers a direct analysis method for determining the structural stability of older buildings, allowing community leaders to make better decisions about revitalization projects.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Consumer Management

- a. *Description:* Research at Purdue has shown that asymmetric pricing in U.S. food markets continues and affects the buying power of the dollar. In particular, asymmetries are found to vary across time, which influences the computation of consumer welfare changes due to asymmetric pricing. Food prices tend to rise more often than fall in response to changes in basic commodity prices.
- b. *Impact:* This research project is leading to a better understanding of the way price changes in major commodity markets affect farmers and other market participants. The results may influence agricultural policies that improve market performance for consumers or producers. As well, the research may be used to develop farm marketing strategies in response to changes in commodity price risk.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Family Resource Management

- a. *Description:* This project is an examination of the individual life histories, day-to-day experiences, as well as the beliefs and attitudes of rural poor women and their families and the links between their experiences and the circumstances within their communities. The goal of the study is to link individual/family experiences to the broader social context of the community, two levels of data-- individual/family and community--were collected. Community level data consisted of public records (newspaper articles, Census Data) over the past three years. Individual/family data entailed a series of three to four open-ended, semi-structured interviews. The sample included low-income women who have at least one child and reside in the same Indiana county.
- b. *Impact:* The findings from this study contribute to research on rural families in poverty by linking individual experience within a community context and describe the lives of rural, low-income women. The study makes the "invisible lives" of some rural, low-income women more visible. As such, the research provides information that is relevant to policy makers, educators, and social service providers as they attempt to better understand the plight of rural, low-income families and to ameliorate poverty in rural areas.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

Key Theme: Tourism

- a. *Description:* In five Indiana counties and seven Indiana municipalities, the most important economic development project in recent years has been the advent of riverboat casinos. Riverboats act as a source of tourism and tax revenues. The casino licenses are up for renewal, and a detailed analysis of their impacts on local communities was conducted (<http://www.in.gov/gaming/reports/index.html>). The research compares the added local government revenues to the added costs generated by the riverboats. For example, in Hammond, Indiana, it was

found that the very large amount of gaming revenue from wagering and admissions taxes paid to the city is much greater than the costs imposed by the riverboats and their employees.

- b. *Impact:* This critical work showed that local tax revenues from riverboats in Indiana greatly exceeds added costs in host counties and cities. In one Indiana school corporation, the new riverboat brought new property tax revenue, but did not reverse the decline in enrollment. The work also shows that riverboats serve as a significant point for tourism, drawing people from adjacent counties and states. More importantly, the report shows the river boats have created jobs and economic opportunities for the associated communities. The fiscal impact from the riverboats was found to be positive. This information will help state and local governments make better decisions about allowing riverboat gambling in their communities.
- c. *Source of Federal Funds:* Hatch and State
- d. *Scope of Impact:* Multistate

B. STAKEHOLDER INPUT PROCESS

Engaging our stakeholders is a priority for Purdue University. Indeed, the Strategic Plan for the entire university makes clear that engagement with state, national, and world audiences is one of the primary missions of everyone at Purdue. In the Schools 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 out in the state. Over one-third of the faculty in School 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, etc. Staff participate in a wide variety of state and local events including conferences, commodity marketing associations, and agricultural interest group meetings. In addition, many of our 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.

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 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 School of Agriculture convenes annual meetings of several stakeholder groups. These often involve direct solicitations of input from participants. A few of these are described below.

Purdue Council for Agricultural Research, Extension, and Teaching

The Purdue Council for Agricultural Research, Extension, and Teaching (PCARET) organization exists at many levels including county, region/area, and state and represents a broad base of stakeholders. At the county level,

the committee members are identified by current PCARET members, county 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 owners.

PCARET holds regional meetings throughout the state in both the spring and fall. At every meeting, representatives from the School of Agriculture attend to update PCARET members on initiatives and programs. At each of the 9 fall meetings, members were engaged in discussions of what Purdue should be doing for the state. A report was developed from these discussions and was shared with administrators as well as PCARET members. In addition, an annual meeting for all PCARET members was hosted on the Purdue campus in November 2001. Sessions were offered to participants on a variety of topics including water quality, genomics, distance learning, and the changing structure of agriculture. Table discussions at each session were focused on questions developed by Purdue staff. Participant ideas were recorded for each session and compiled into a report that was shared with each department in the School of Agriculture.

Dean's Advisory Council

The Dean's Advisory Council (DAC) is made up of representatives from primary and secondary education, producers, farm input industries, banking, agriculture and community associations, the legislature, environmental organizations, and others. Members are chosen by the Dean with input from the Department Heads. The primary purpose of the DAC is to provide broad client input to the Dean and Associate Deans for Research, Teaching, and Extension. The DAC meets twice a year.

During the fall meeting in October of 2000, members of the DAC were broken out into small groups and asked to discuss six topics of concern to the School of Agriculture. One of these topics included the linking of research with economic development. The group then developed a brief report on their discussions for distribution to the entire DAC and Agricultural Administration.

School of Agriculture Roadmapping Retreat

As Purdue set out to develop a strategic plan for the entire University, the School of Agriculture undertook a roadmapping activity to help lay out a plan for reaching "the next level" in learning, discovery, and engagement. Stakeholders from around the state were invited to join selected administrators and selected faculty at a daylong retreat that kicked off our roadmapping effort. 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 the group identify 14 different issue areas to be developed into action plans by separate committees. Stakeholder input from the retreat was compiled for use by 14 smaller issue-oriented committees.

Indiana Plant Food and Agricultural Chemical Association

The Indiana Plant Food and Agricultural Chemical Association (IPFACA) is composed of individuals from the agricultural service community in Indiana. A typical member sells agricultural chemicals or fertilizers or manages a retail operation. Members are often also farmers or have farm backgrounds. A Purdue University faculty member serves on the board of directors of IPFACA in an ex-facto status. Meetings of the IPFACA board of director are held monthly where ideas and issues are discussed. The group also has an active email list and web site where information is exchanged. Over the year, some 400 individuals from the agricultural service community attended events sponsored by IFPACA and Purdue.

At the winter educational meeting, attendees were asked for input concerning the responsiveness of Purdue University to the needs of the agricultural chemical industry. Questions addressed areas where Purdue University could improve our transfer of information. In particular, we asked 1)How well does Purdue meet information needs in soil fertility, environmental quality, pesticide use, new crops, genetically modified crops and land application of waste materials?, 2) What areas of research are important?, and 3) Do they use the WWW to get information on Purdue's research efforts?

Consideration of Collected Input

Reports were generated from meetings and conferences where stakeholder input was solicited. These reports were distributed to Associate Deans and relevant Departments for their consideration. The information generated through engaging our stakeholders will be valuable as the School's roadmapping and planning activities continue. Developing and implementing the roadmap will be a continuous and iterative process and will be the primary mechanism by which stakeholder input is considered and addressed.

One comment repeated in many stakeholder discussions was that we needed to do a better job at communicating research programs and results to the state. We are addressing this concern by developing an electronic digest of research-related new releases. This will be distributed every few months to DAC and PCARET members, industry representatives, other experiment stations, and others who wish to subscribe.

C. PROGRAM REVIEW PROCESS

Agricultural Research Programs manages the research portfolios on the principle of one research project per investigator. Project proposals are reviewed as described in the Plan of Work.

D. EVALUATION OF SUCCESS OF MULTI AND JOINT ACTIVITIES

Faculty in Agricultural Research Programs have been involved in over 100 multistate projects as participants in the formal program of multistate research and information project (MRIP) managed through the four Regional Experiment Station Executive Director offices. Projects have a broad disciplinary base. The MRIP has projects that are relevant to each of the five CSREES goals.

Alfalfa stand persistence is impacted by various abiotic and biotic factors. A North Central regional committee has developed a standardized protocol for measuring stand persistence, including the separate measurement of alfalfa yield components: number of plants per unit area, number of shoots per plant, and mass per shoots. They are identifying and characterizing changes in physiology, biochemistry, and gene expression associated with

pest injury including analysis of starches, sugars, nitrogen pools (amino acids, protein concentration and composition) in roots and crown buds exposed to stress. This information will be used to create improved fertilizer recommendations for producers that will ensure high forage yield with appropriate P and K fertilizer inputs.

Crop growth and development models require total daily solar radiation values, but this is rarely measured. A North Central regional committee has developed a GIS database with estimated daily total solar radiation for the period of record for each county in the region using interpolation values from the Meyers and Dale (J. Climate and Applied Meteorol. 22:537-545) model.

The Five State Beef Initiative is a unique partnership between producers, beef cattle associations, land grant universities, state departments of agriculture, Farm Bureaus and a livestock marketing cooperative in IL, IN, KY, MI, and OH. The goal is to help small to medium-sized beef producers in the Eastern Corn Belt capture more value from their cattle by meeting consumer expectations through a responsive production, marketing and information sharing system. Producers will be required to attend a training/certification workshop to participate in the FSBI program. The bottom line is to increase the value of the live animal throughout the production chain as well as all parts of the carcass. Consumers demand more from the food they eat which has resulted in an increase in the number of niche market and value-added opportunities for producers. All consumers expect beef products to be safe and wholesome. However, some markets demand, and will pay more for the assurance that cattle are Beef Quality Assurance/health certified, raised under animal well-being and environmental guidelines, source verified, and have known genetic backgrounds. The FSBI will allow both the animal and carcass cuts to enter into any of these consumer driven, value-added market opportunities that will increase animal value. Certification of producers will document and verify that producers have been trained in: 1) Beef Quality Assurance)/animal health; 2) animal handling/well-being; 3) environmental stewardship; 4) genetics; and 5) the use of performance, carcass and economic data.

Identification of the most salient motivators and barriers influencing the consumption of calcium rich food is essential for growth and health among adolescents. Eleven states are actively involved in a multistate project addressing children 11-12 and 16-17 years representing Asian, Hispanic, and white groups. Indiana took the lead in determining the calcium values for each of the 80 food groups in the semi-quantitative food frequency questionnaire designed for assessing calcium intake in children 10-18 years. Indiana participated in the construction of a combined motivator/barrier questionnaire and food frequency questionnaire. A total of 389 Hoosier children completed questionnaires. The results from this project will be used to design effective, tailored nutrition intervention among preadolescents and adolescents, likely reducing their risk of osteoporosis later in life.

New apple cultivars are continuously being developed around the world. Both the apple industry and university scientists are working on a unified system for rapid field evaluation of new cultivars. NE-183 (Multidisciplinary Evaluation of New Apple Cultivars) was established in 1994. Scientists at 25 experiment stations in the United States and Canada were evaluating apple cultivars, previously. However, under the new regional project differences in planting dates, rootstocks, cultivars evaluated, and data collection methods are managed in a more consistent and coordinated fashion. In recognition of NE-183, and other successful regional efforts such as NC-140, a Purdue scientist who Chairs NE-183 accepted on behalf of this regional effort the USDA Secretary's Award for Research in Washington DC in June 2001.

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

Institution	Purdue University
State	Indiana

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

Annual Expenditures

Name of Planned Program/Activity	FY2000	FY2001	FY2002	FY2003	FY2004
Cooperative Institute for Commercial Producers		13,073			
Analysis of Trade Liberalization, Domestic Policies, and Subsidies		34,429			
Genetic Technology Developed at Purdue to Combat Soybean Cyst Nematode		44,836			
Improving Safety of Ready-to-eat Meat Products		16,355			
Development of Management Options for the Soybean Pest: A Potential Pest of Soybean in Indiana		3,890			
Development of an Economic Threshold for Western Corn Rootworm in Corn Based on Numbers of Adults in Soybean		3,890			
Human Pest Management		5,958			
Evaluating the Impact and Use of Ractopamine on Pig Production		20,638			
Developing a Better Alfalfa Plant		2,266			
Safe On-Farm Quality Assurance Program		458			
Total		145,793			

E. INTEGRATED RESEARCH AND EXTENSION ACTIVITIES

Executive Institute for Commercial Producers

The current economic environment places significant demands on large commercial producers to position their business for success and take on the role of a general manager. The undirected growth typical of farms in the past will not be acceptable. To do this managers must have a comprehensive set of finance, marketing and strategic tools.

Purdue faculty moved farmers with the potential to be highly successful through a series of seminars over the course of a year. Participants were drawn from leading agribusinesses in the four states (Indiana, Ohio, Kentucky and Tennessee) that Farm Credit Services of Mid-America serves. These seminars introduce and apply advanced business management concepts to the problems confronting the larger and more complex commercial farm and its management team. The classes consist of intensive one-on-one strategic consultation, group work, case study analysis, and computer skill development. This multi-state effort will continue for the next two years. Visit the website at <http://www.agecon.purdue.edu/ext/eicp>.

Since the conception of the project in early 2000 there has been a marked evolution in how farm managers view the strategic focus of their businesses. While gaining skills in the short-term financial control of their business, participants have developed a long-term view of the profitability of their business essential to success. Participants have also increased their computer skills and developed a network of peers. The first class (of three) of 23 operations indicated the material presented to be highly useful in dealing with managing their business. On a scale of five, the program has been rated a 4.56. One participant said “As we grow our business, there are a lot of challenges ahead for the future that we need to address. At these seminars, we've learned how to manage our assets, how to manage our resources, and how to manage our employees. Also, we've looked at how to think about growing the business. These are things for the young farmers and nurserymen of the future to be aware of - or we won't be in the business.” Future impact of the program will include packaging of the material for extension educators in the four-state region.

Analysis of Trade Liberalization, Domestic Policies, and Food Subsidies

Developing countries often have conflicting objectives in their domestic and agricultural trade policies. Also, the domestic policies may not be attuned to the climatic reality in the country or to accomplishing more holistic rural development objectives. This project is helping these countries to create a more comprehensive set of trade and domestic policies and to developing strategic plans for rural development in the region. There were two major activities and outputs this year: (1) Analysis of the linkages between agricultural policies and climatic reality in Morocco, and (2) Strategic planning for rural development in North Africa and the Middle East. The impact of the research to better align agricultural policies to climatic reality is already being felt in policy formation and implementation in Morocco. There is significantly increased consideration of climate variability in policy analysis. New tools for policy analysis are being developed to directly incorporate risk analysis into policy decisions. A summary of the tools needed was included in the paper presented in Morocco this year. The immediate impact of the World Bank rural development strategy work has been to reach consensus among participants on the need for holistic approaches to rural development and for active community participation in designing and implementing development projects. Another impact has been that MENA countries have

launched their own rural development strategy processes, many using the framework developed for this project. Longer term, as countries implement their strategies, we should see more success in agricultural development programs in the region.

CystX Technology Developed At Purdue To Combat Soybean Cyst Nematode

Soybean cyst nematode (SCN) is the most destructive pest of soybeans nationwide, with an estimated annual loss of \$1.4 billion in the United States. Plant resistance is the main tool for managing SCN. Purdue University's patented soybean germ plasm now known as CystX technology provides the only source of complete and broad-based resistance to SCN with no yield drag that can be easily incorporated into high yielding lines by breeders using conventional methods. In order to make the transfer possible from academia to the marketplace, breeders had to be convinced that the CystX technology would work. Researchers at Purdue and the Indiana Crop Improvement Association (ICIA), developed and demonstrated the efficacy of the new product and Access Plant Technology was authorized to devise the trademarked logo, CystX, and to assume responsibility for promoting and licensing the CystX technology to breeders across the country. CystX technology is becoming a "win:win" scenario for all involved in its development plus the subsequent transfer to the marketplace. CystX is a good example of the development and transfer of timely and useful technology from the academic laboratory to the marketplace.

Improving Safety of Ready-To-Eat Meat Products

Low levels of *L. monocytogenes* (LM) on the surface of ready-to-eat (RTE) meats can be life threatening, particularly to immune-compromised individuals, the elderly and unborn fetuses. USDA has issued a zero tolerance for LM in any food product. Thus, packaged RTE meat products must be free of all viable *L. monocytogenes* microorganisms. However, under current manufacturing practices, surface contamination can occur before final packaging via aerosols or handling after the product has been initially pasteurized. Purdue faculty have developed a post-package pasteurization process for sliced bologna that eliminates the threat of food illness caused by LM contamination. The process will prevent illness associated with LM from commercial sliced, RTE meat food products. In addition, the availability of individually packaged bologna slices, like that in single-serve cheese slices, will be a convenience to consumers. Finally, the shelf life of individually wrapped, post-pasteurized packaged bologna will be longer. This is because the pasteurization also reduces the population of all micro-organisms that could lead to spoilage and because each slice of bologna is protected from contamination until it is opened for use by the consumer.

Development of Management Options for the Soybean Aphid: A Potential Pest of Soybean in Indiana

The soybean aphid (SA) is a recent invasive species in Indiana. It was first found in Northeastern Indiana in 2000, although subsequent surveys late in the 2000 growing season showed that it was present in every county surveyed (46). It is unknown at this point how serious this pest will be in soybean. To address this issue, research plots were established in 2001 to 1) determine if planting date affects SA colonization/soybean injury, 2) determine if cultivar affects SA colonization/soybean injury, 3) begin economic injury level determination studies, and 4) evaluate potential control products. Also, from an extension standpoint we developed ways to address SA concerns and need for information by producers and other agribusiness personnel. Surveys to determine the immediate threat of the SA were also conducted. The propensity to treat Indiana soybean to manage the perceived threat from SA was countered with aphid population survey information that showed little risk in 2001. This prevented unnecessary chemical applications and associated costs to producers

estimated to range from \$500,000 to \$1,000,000 statewide and prevented unnecessary environmental exposure. In those cases where treatment may be justified in the future, field research studies have identified several registered and experimental insecticides that have potential to efficiently manage SA. Additionally, it appears from data generated in 2001 that early planted or early maturing soybeans are less likely to experience economic levels of SA. A 4-page color fact sheet (E-217) was also produced and distributed.

Development of an Economic Threshold for Western Corn Rootworm in Corn Based on Numbers of Adults in Soybean

Western corn rootworm (WCR), once considered only a pest of corn, has adapted to the corn/soybean rotation production system in parts of Indiana, Illinois, Ohio, and Michigan, by laying eggs in soybeans. Rootworm larvae damage corn planted in the year following soybean thereby diminishing the value of crop rotation as a cultural management technique. This has resulted in increased and sometimes indiscriminate use of insecticides in the affected area. Pherocon AM yellow sticky traps were established in multiple soybean fields over several years to determine WCR adult numbers and subsequent damage by WCR larvae to corn roots. Data were analyzed to determine management threshold values. Test results from studies designed to develop treatment thresholds for corn based on the abundance of adult WCR observed in soybean in the preceding year indicated that the research-based treatment threshold to prevent economic injury to corn in the following year using yellow sticky cards is 8 beetles per trap per day. For extension purposes, however, the economic threshold of 5 beetles per trap per day was selected as the recommended level for farmers based on the fact that > 95% of the first-year cornfields reached economic root damage the following year when this number was attained. Knowing when the economic threshold is reached in soybeans in the preceding season allows corn producers to more efficiently manage this pest. The judicious use of soil insecticides intended to protect corn roots in Indiana has the estimated potential savings (preventing unnecessary insecticide applications and protecting crops at risk) of hundreds of thousands of dollars annually. A fact sheet (E-218) was produced and distributed to agriculturalists in affected areas.

Urban Pest Management

Cockroaches, ants and termites are the most serious threats to our property, health and food supplies. Purdue research helped to better understand these pests and develop pest management strategies to reduce their impact on our lives. Thousands of property owners, apartment dwellers and professional pest managers have utilized this research and continuing education programs to resolve their pest problems in an environmentally sensitive integrated pest management program. New technology on traps, baiting, and sanitation has been made available for cockroach, ant and termite management programs.

Modeling the Impact and Use of Ractopamine on Pig Production

The genetics of pigs have changed as has the swine marketing systems. Elanco publicly released ractopamine (Paylean®) July 7th, 2000 with little information on the correct nutrition, duration of feeding, marketing and management of Paylean fed pigs. Ractopamine, only when combined with the correct nutrition (increased lysine/protein levels) and fed the correct length of time and level will result in substantial improvements in the efficiency of lean pork production. Five research trials have been completed at Purdue evaluating the response of current genetic populations of pigs to Ractopamine (Paylean). The research trials have looked at the effect of different lysine levels, the response over time, the interaction with alternative genetic populations, energy levels and joint response with CLA (conjugated linoleic acid). One trial was completed jointly with the University of

Illinois, which looked at pork quality and shelf life. Also one trial looked at the effect of increasing or decreasing the level of Paylean. The analysis is being used by Paul Preckel and his associates to model the optimal use of Paylean. The results of these trials were put on the Purdue Pork Page website and referenced as the best single source of Paylean information by each major national swine publication, website and electronic newsletter. This information has been used by ELanco in regional seminars held across the United States. The use of Paylean has increased to 20 % of the pigs in the United States - resulting in an increased profit of \$ 2.00 to \$ 3.00 per head to the pork producer and the same amount to the pork processor due to the increased percent lean.

Building a Better Alfalfa Plant

Alfalfa yield and persistence have not improved substantially in the last 40 years despite enormous effort put forth by the commercial alfalfa breeding industry. Genomics is thought by many to be a more concise approach to crop improvement, but to use these modern tools we must know what processes, proteins, and genes control yield and persistence of alfalfa. Purdue research and extension staff are using an integrated approach that includes physiological, biochemical, and molecular genetic tools to understand factors that influence growth, yield, and persistence of alfalfa. Work is being done in the field with plants selected for key traits (hardiness, growth rates, dormancy) and tissues are being sampled throughout the year, including winter, in order to understand how genes of interest are being influenced by environment or management. Genes have been identified that are consistently associated with excellent winter survival. Work is being initiated to better understand processes and genes involved in rapid shoot growth that results in high yield. Purdue faculty are identifying traits or genes that can be used as selection criteria to improve alfalfa yield and winter hardiness using conventional breeding or molecular genetics. By understanding the biology of alfalfa, we will define functions that are key to improved agronomic performance, and ultimately put the "function" in functional genomics.

GrainSafe On-Farm Quality Assurance Program

Purdue faculty started a project to establish an on-farm quality assurance program that will meet the needs of Indiana producers, handlers and processors of value-added grains and oilseeds with respect to food (and feed) safety and end use quality, and to maximize the opportunities of marketing Indiana quality-assured grains and oilseeds with confidence to domestic and international end-users through a voluntary auditable Code of Good Agricultural Practices. Although Indiana farmers already have a very good record of producing safe grain of good quality, the GrainSafe program will provide them with a simple and effective mechanism for satisfying customer requirements for food and feed safety quality assurance. The message to farmers is: "GrainSafe doesn't tell you how to farm, it tells everyone else HOW WELL you farm!" An on-campus working group has been established that is currently developing HACCP-based checklists that identify hazard control points, quality management steps, and corrective action procedures needed to complement best management practices for the production, handling and delivery of quality-assured grains and oilseeds. Throughout this year, the GrainSafe program concept has been presented at numerous meetings and sought reactions and input from producers, grain handlers, equipment and service suppliers, and other agricultural professionals. Their feedback will be incorporated into the GrainSafe program, which will be further developed by a task force representing Indiana stakeholders. This approach will ensure that the first person to benefit from this quality assurance program will be the farmer who implements it. This project continues to stimulate significant discussion among agricultural professionals because certifiable quality-assured crop production is emerging as a hot topic in light of the debate over the impact of genetically modified (GM) crops on domestic and global markets. It is expected

that the beneficiaries of the GrainSafe program adoption will include farmers, handlers, processors, marketers, end users, and consumers of Indiana grains and oilseeds.