Annual Report of Accomplishments And Results

Agricultural Research Programs
Purdue University

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Submitted by:
William R. Woodson
Associate Dean and Director
Agricultural Research Programs

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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. For 2001 (the most recent year available), cash receipts for Indiana agriculture were $5.1 billion with 63% from crop sales and 37% from livestock sales. The 63,000 farms in Indiana represent 3% of all U.S. farms. In 2001, Indiana agricultural exports were estimated at $ 1.58 billion, 3% of total U.S. agricultural exports. Despite being a relatively small state with only 1.6% of total U.S. cropland, Indiana ranks second in egg, processing tomato, and mint production; third in soybean production; fourth in corn production; and fifth in hog production. The challenge for Indiana farmers is to adopt and manage agricultural production practices that are environmentally sound, yet allow them to remain competitive in a dynamic global economy.

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. Purdue University scientists are leading the way in genomics, proteomics, and nanotechnology. Indiana farmers are adopting transgenic crops. In 2002, 13% of the field corn and 83% of the soybeans produced in Indiana were transgenic varieties. Purdue University researchers seek to understand and exploit the genetic basis for plant, animal, microbial and insect form and function. Fundamental and applied research in genomics, proteomics, molecular biology, and bioinformatics are the foundation for the development of value added/identity preserved products. Purdue University scientists are engaged in a wide array of genetic research including development of DNA vaccines for poultry, Arabidopsis gene function discovery, and isolation of genes responsible for aggressive behavior in bees. Such discoveries can increase the profitability to farmers and the entire food value-chain by improving the productivity of crops and livestock, and adding value to agricultural products.

Plant productivity is challenged by numerous biological and non-biological stresses. Purdue University is making a significant investment in research to mitigate the impact of potential economic losses from pests and plant stress. Pests, such as the Western corn rootworm, have recently adapted and evolved to counter crop rotation as a biological control strategy, thus resulting in damage in first-year corn. Invasive species regularly enter agricultural system such as the soybean aphid first discovered in Indiana in 2000. Purdue University researchers are exploring a variety of approaches to reduce potential pest losses including genetic resistance to pests, insect management on an areawide versus single field basis, biological control, and fewer chemical treatments by following Integrated Pest Management strategies.

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

The challenge of ensuring the health and well being of animals, while maintaining maximum production remains important to Indiana producers. Purdue University researchers are working to ensure that livestock are raised under conditions that minimize diseases and stress, maximize productivity, reduce environmental pollution, and are managed in ways acceptable to consumers. Researchers are working to eliminate gastric ulcers and bleeding disorders in pigs, reducing excess nitrogen and phosphorus in animal manure, and finding ways to improve the well-being of swine while making them more productive.

U.S. agriculture is challenged by a very competitive global economy. Major contributors to the globally competitive position of U.S. agriculture include the development of biotechnology, rapid international flow of capital, changes in business structure, international trade agreements, domestic agricultural and environmental policies, rapid advances in information systems, just-in-time transportation systems, and electronic marketing systems.

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

Purdue University is providing Indiana farmers and businesses with opportunities to compete in new markets and obtain greater economic benefits. 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 on the quality of life for everyone. Purdue University research in this area is closely linked with our various stakeholders and extension educators around the state as together they seek to create new uses for agricultural products, while making more efficient use of natural resources and increasing the competitiveness of producers and agribusiness. One way this is being achieved is through the breeding or genetic modification of grain to make crops more valuable for food, processing, new materials, or energy production. Research programs are also addressing ways to use carbohydrates and oilseeds to make industrial products, such as substitutes for petroleum-based polymers, bio-based fuels, or enhancing the nutritional quality of grains for livestock. Other researchers are looking for new uses of agricultural products and by-products as feed for livestock and fish.

Successes:

- Management intensive rotational grazing reduces feed costs for brood cows.
- Adding phytase and 25-hydroxycholecalciferol to turkey diets with lower phosphorus levels results in weight gains.
- Reducing crude protein and supplementing swine rations with amino acids and fiber reduces odor without sacrificing swine growth performance and carcass quality.
- No-till corn and soybeans yields can be superior to those with conventional tillage.
- Non-intermeshing rubber conditioning rolls and a hay tedder reduce drying time.
- Studies of Africanized and gentle European honey bees provide insights into the genetic traits that influence stinging behavior.
- The callipyge locus on chromosome 18 in sheep results in increased muscles in the loin and pelvic limbs.
- A sorghum mutant has been identified that has substantially greater protein digestibility.
- A mutant Arabidopsis has been identified with increased permeability of small molecules.
- Microsatellite markers produce a unique DNA fingerprint for hardwood trees such as oak, cherry, or walnut.
- Basic research on the Arabidopsis facilitated gene discovery in agronomic crops for salt and drought tolerance.
- Glyphosate-tolerant corn and soybeans are less efficient in manganese uptake in low manganese soils.
- Supplementing vitamin K in swine rations reduces bleeding disorders.
- Therapeutic antibiotics in livestock feed reduces the severity of gastric ulcers.
- An in-house manure turning machine reduces fly larvae in commercial caged pullet operations.

- Development of biosecurity procedures that prevent the transmission of *E. coli* and foot-and-mouth diseases require personnel to shower and use clean clothes after an encounter with infected animals to prevent infection of other animals.
- Market cartels with monopoly power raise the selling prices of their products.
- Suppliers of agronomic inputs are initially adopting the less capital-intensive precision farming technologies.
- Trade liberalization can reduce poverty in agricultural-specialized households, but the socioeconomic impact is mixed in other households.
- Magnetic resonance detection can be used in a non-destructive way to measure the quality of fruits and vegetables.
- Soy-proteins replace animal-proteins in gelatin desserts.

Benefits:

- Fewer days of winter hay feeding using an intensive grazing system can save $50 per brood cow per year.
- Turkey diets supplemented with phytase and 25-hydroxycholecalciferol reduce litter phosphorus concentrations by 42%.
- Reducing crude protein in swine rations with supplemental amino acids and fiber reduce odor and land requirements for nutrient management.
- Early corn planting with polymer treated seeds reduces the risk of poor plant establishment.
- Reduced hay drying time can increase the feed value of hay and reduce the cost of feed supplements.
- Understanding the genetics of callipyge phenotype in sheep can increase muscle development and carcass quality.
- Increased digestibility of sorghum protein is nutritionally beneficial to children in low-income, sub-Saharan African countries.
- Understanding plant cuticle biochemistry will help in the design of herbicides for better weed control.
- Genomics is enhancing the development of hardwood trees more suitable for the furniture industry.
- Adequate levels of micronutrients such as manganese are critical for plant growth and disease resistance, especially for glyphosate-tolerant corn and soybeans.
- Swine rations should be supplemented with vitamin K to prevent porcine hemorrhagic syndrome.
- Inedible, undergrade, or low-value eggs can be used effectively in diets for segregated early weaned pigs.
- Turning manure in poultry operations reduces the adverse impacts of fly populations, fly control costs, and the environmental nuisance of fly activity.
- Biosecurity protocols must be followed to prevent the transmission among farm animals of exotic diseases such as foot-and-mouth disease.
- The monopoly profits made by the cartels are often greater than the financial costs incurred by cartels through fines and legal settlements to private plaintiffs.
- Agricultural input firms are bullish on the prospects for e-commerce.
- The Global Trade Analysis Project (GTAP) modeling approach and database are being utilized for trade policy analysis by 1500 researchers in more than 90 countries.
- Soy-based desserts are creating a new market for soybeans.

State Assessment of Accomplishments:

Research at Purdue University is addressing the needs of various diverse stakeholders. Research spans a very broad base, including, developing animal diets to reduce adverse environmental impacts from waste; evaluating new technologies as tools for agricultural competitiveness; evaluating contractual and structural options for producer competitive positioning; increasing the efficiency of plant growth, and developing the base for value added products that have the potential benefits for consumers and producers.

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

Key Theme: Agricultural Profitability (1)

a. *Description* - Feed costs account for 50 to 60 percent of the total annual costs of maintaining beef brood cows. Purdue University researchers evaluated the influence of grazing systems upon the performance and economic return of grazing beef cows and their nursing calves. Based on three years of results, beef cows in a management intensive grazing program (six to eight paddocks, rotationally grazed) require 30 to 60 fewer days of winter feeding versus cows in a traditional grazing system (two paddocks rotationally grazed).

b. *Impact* - With fewer days of winter-feeding, annual cost savings of $50.00 per cow can be realized. Cow reproductive performance and calf-weaning weight was not influenced by grazing system. During a 60 day period (Nov. to Dec.), dry-fed cows consumed 1600 to 1700 pounds more hay compared to cows in the other two systems. Feeding cost per cow during the 60-day period was $6.60, $15.00, and $69.00, respectively, for corn crop residue, fall saved pasture and dry-lot. Cows in dry-lot maintained body weight and condition, whereas those on the other two systems gained body weight and condition. This research was conducted at two Purdue University research farms located in southern Indiana where farmers regularly attend twilight meetings to learn more about research results.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Agricultural Profitability (2)

a. *Description* - A total of 128 Angus-sired steer calves (initial bodyweight 304 kilograms) were used to evaluate the effects of increased number of days fed on live performance, carcass traits, and net return. Steers were randomly allotted by weight to one of four harvest dates (131, 152, 173 or 208 days) on a high grain ration. Cattle were priced using either a common carcass grid ($120/cwt base) or live price ($76.36/cwt). When cattle were priced on a live basis, net return/head increased linearly, while grid pricing approached significance in a quadratic manner. While price and cost assumptions used in this study resulted in greater profits when steers were sold on a constant live price basis, true value is more accurately reflected by the grid pricing mechanism. Net returns were maximized when calves were fed approximately 173 days.

b. *Impact* - Cattle feedlot owners/managers in Indiana, as well as the rest of the United States constantly face the decision of when to market their cattle. Cattle marketed prior to their optimum stage of production may be discounted up to $60 per animal due to inadequate marbling or up to $135 per animal because of a lightweight carcass. Conversely, cattle marketed too late in the finishing phase may incur discounts from $100 to $140 per animal due to excessive backfat. Information generated in this project offers cattle producers a management tool that will enable them to make more informed decisions as to when to market cattle to maximize net return potential.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Animal Production Efficiency (1)

a. *Description* - Twelve crossbred barrows fitted with steered ileo-cecal valve cannulas were used in a 6 x 6 Latin square design to test the effects of phytase on amino acid apparent ileal digestibility and to determine endogenous amino acid digestibility using an enzymatically hydrolyzed casein diet. The addition of phytase to a low crude protein diet did not improve the digestibility of lysine, methionine, threonine, tryptophan, or crude protein.

b. *Impact* - Using an enzymatically hydrolyzed casein diet to estimate amino acid losses in the pig may provide a more accurate measure of amino acid availability.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Animal Production Efficiency (2)

a. *Description* - An experiment was conducted to determine the feasibility of lowering phosphorus levels when phytase and 25-hydroxycholecalciferol are added alone and in combination in diets for turkeys. Male, Nicholas poults were fed one of nine diets. Birds fed the industry and National Research Council diets were heavier from 0 to 15 weeks compared to toms fed the low phosphorous.

b. *Impact* - Reductions of dietary phosphorus when phytase and/or 25-hydroxycholecalciferol were added to the diet did not significantly affect tom performance. When fed to phosphorus requirements and diets supplemented with phytase and 25-hydroxycholecalciferol, litter phosphorus concentrations were reduced 42 percent versus birds fed a typical industry diet.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Animal Production Efficiency (3)

a. *Description* - Experiments were conducted with grow-finish pigs to evaluate dietary manipulation to reduce aerial pollutants and nutrient excretion. Four different experiments were conducted. Pigs were feed different concentrations of crude protein, amino acids, fiber, and phytase. Samples were taken at various weekly intervals. Manure samples were also collected. Loin depth, backfat, growth performance and carcass characteristics were compared .

b. *Impact* - Reducing the crude protein and adding supplemental synthetic amino acids and fiber to the swine diet significantly reduced nitrogen excretion, ammonia and odors. In addition, using high available phosphorus corn and phytase significantly reduced phosphorus excretion. Economical diet manipulation will reduce land requirements for manure disposal, offensiveness of odors and maintain profitable pig performance. This will allow pork production to be environmentally sustainable and compatible with rural residents.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Innovative Farming Techniques (1)
FY '02 Focus Area: Improved Pest Control and Food Quality and Protection Act Implementation

a. *Description* - The evolution of a Western corn rootworm "variant" in the Eastern Corn Belt has significantly reduced the viability of a traditionally effective corn-soybean rotation. Consequently, corn growers in parts of Illinois, Indiana, Michigan, and Ohio have increased their reliance on soil insecticides to manage rootworms. Several of the commonly applied soil insecticides are organophosphates and are currently under review by the Environmental Protection Agency. To better understand current and future management practices, a survey was mailed in February-March 2001 to 6,000 Indiana farmers (19% response rate). In northwestern Indiana where the rootworm variant is most prevalent, 75% of the respondents reported using soil insecticides while south of Interstate 70 only 25% of the rotated corn acres were reported to be treated with a soil insecticide.

b. *Impact* - Growers expressed moderate willingness (about 30%) to adopt an areawide pest management system currently under review by the USDA-ARS and several Midwestern land grant universities. With an areawide system growers collectively scout fields and aerially spray adult beetles with a semiochemical bait. Respondents who operate larger farms, who frequently obtain information from extension educators, who are concerned about the cost and future availability of organophosphates, and who have education beyond high school are very likely (at least 45%) to adopt transgenic corn to control corn rootworms. These results have been shared with stakeholders via newsletters and on-site grower meetings.

c. *Source of Federal Funds* - Hatch and USDA-ARS

d. *Scope of Impact* - Corn Belt States

Key Theme: Innovative Farming Techniques (2)
FY '02 Focus Area: Sustainability of Agriculture and Forestry

a. *Description* - Tillage, nutrient management, and planting dates are critical to increasing corn yields. In field research conducted on Purdue University research farms in West Central and Northwest Indiana, no-till corn and soybean yields were similar to - or superior to - those with conventional tillage even when excessive precipitation levels occurred in the spring of 2002. Zone tillage (particularly, fall strip tillage) has the advantage of maintaining essentially the same surface residue cover as no-till, but with the advantage of earlier soil drying in spring, warmer seedbeds, and improved yield consistency relative to conventional tillage systems on the same soil type. Zone tillage studies involving alternate depths of nutrient placement have been underway for the past three years with high oil corn. Banded potassium placement for improved crop yields and improved seed quality have been documented on soils where nutrient stratification has occurred after long-term conservation tillage practices. To extend the corn planting season, polymer coated seeds were planted three to four weeks earlier than the optimum planting date in Indiana.

b. *Impact* - Early planting with the polymer coated seeds reduces the risk of poor plant establishment. The system is particularly beneficial in no-till corn planting systems (since these producers typically have fewer planting days available in the optimum planting period in wet springs such as 2002), or for producers who are limited in their equipment or planting resources. Corn yields were not consistently higher with ultra-early planting with all hybrids or in all environments. Thus, Indiana and Midwestern farmers should only adopt this system if they select hybrids capable of tolerating early season stresses like cool, wet soils for prolonged periods.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Corn Belt States

Key Theme: Innovative Farming Techniques (3)

a. *Description* - Baling hay in the Midwest is challenging due to risk of rainfall. Rain damage has been documented to reduce dry matter yield 37 percent and protein by 46 percent. In Indiana, millions of dollars are lost annually due to yield and feed value reduction from rain damage. Alternative non-intermeshing rubber conditioning rolls and a hay tedder can reduce drying time. Five experiments were completed in North Central Indiana for alfalfa, orchardgrass, and alfalfa/orchardgrass mix. The alternative conditioning rolls significantly reduced drying time in alfalfa up to 2.1 hours, and orchardgrass up to 3.3 hours. The tedder reduced drying time by 1.7 hours in alfalfa, but did not significantly decrease drying time for second-harvest orchardgrass..

b. *Impact* - Larger acreage operations with high-value forage would be economically better positioned to justify the additional cost of the alternative conditioning rolls and produce more tons of non-rain damaged hay. These producers can justify the extra expense of retrofitting or purchasing a new mower-conditioner with the alternative conditioning rolls. This can reduce the expense of feed supplement cost and increase market share for purchased hay from Indiana farmers. These research results have been demonstrated to growers at Purdue Hay Days on the Purdue University research farms.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Midwestern United States

Key Theme: Precision Agriculture (1)

a. *Description* - A laboratory apparatus was constructed to study variable-rate seeding, and to map as-applied planting. Commercially available electronic controllers and monitors were used to vary the seeding rate. A laptop PC simulated message strings transmitted by a mobile Global Positioning System receiver tracing a predetermined path. The field speed was manually adjusted. The desired seed population could be manually adjusted or determined automatically from a planned variable-rate map. The planting rate (seeds per minute) was measured, and the seed population was calculated to verify the system calibration. A sensor in the seed drop tube provided an as-applied signal which was mapped and compared to the desired population map. The automatic recording and reporting of as-applied, variable-rate seeding is an essential step in developing site-specific information technologies for machine operations. The variable-rate seeding simulator can be used to determine the accuracy of controllers when speed and population changes.

b. *Impact* - The capabilities of variable-rate technologies for seeding have been demonstrated in a laboratory setting. The next critical step will be to educate and train farmers.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Precision Agriculture (2)

a. *Description* - Field research was continued to evaluate site-specific crop management technologies for corn (*Zea mays L.*) and soybean (*Glycine max L.*) production in the eastern U.S. Corn Belt. A study conducted on 49 hectares at the Davis-Purdue Agricultural Center in East-Central Indiana evaluated the performance of several geo-statistical interpolation methods, with and without the aid of secondary information (remotely sensed imagery), at relatively intense (1 sample/0.2 hectares) and sparse (1 sample/1 hectares) soil sampling densities. Among four methods compared, simple Kriging with varying means proved to be the best method for sampling densities for mapping soil organic matter variability. Another study conducted on three no-till 12 hectare farmer fields in West-Central and East-Central Indiana investigated whether the spatial pattern of soil core collection following a corn crop influenced the measured values resulting from soil sample analysis for specific sample grid areas of fields. The spatial pattern of soil core collection did not affect the resulting soil test data values for soil phosphorus, pH, organic matter, or cation exchange capacity. Soil core collection patterns that included sampling from the middles of the previous corn crop rows resulted in slightly higher soil potassium values than those patterns that involved sampling only from within the old corn rows. Yield monitor calibration on 12 hectare fields at the Davis-Purdue Agricultural Center in East-Central Indiana and the Purdue Agricultural Center in Northeast Indiana found that if the monitor is only calibrated at the beginning of the season errors in both yield and grain moisture estimates will increase over the course of the harvest season.

b. *Impact* - A representative of a major seed company said with respect to this precision farming research conducted by Purdue University scientists, “Our company utilizes internal and external sources for answers to questions that help keep our customers profitable. When the industry and public recommendations match, growers realize that they can trust both sources and we all win.”

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Organic Agriculture
FY ’02 Focus Area: Organic Agriculture, Production, and Processing Methods

a. *Description* - Plots to evaluate organic controls for apple maggots were established at the Horticultural Research Farm, West Lafayette, Indiana. Imidan treatments were applied using a tractor-mounted sprayer with a handgun nozzle. Eight applications of Imidan at a rate of four pounds per acre were made at 14-day intervals. Other treatments included either one or four sticky spheres per tree, and attract and kill spheres. Red sticky spheres were coated with Tanglefoot and placed in trees in mid-June. The attract and kill treatment consisted of a red plastic sphere identical to the sticky spheres, with no Tanglefoot. At harvest, 25 apples from each tree were inspected for the presence of apple maggot damage. Apple maggot damage was relatively light in the plots. There were few significant differences between treatment means. The only apparent trend was that trees with sticky spheres tended to have more apple maggot damage than trees without sticky spheres, with trees with four spheres resulting in significantly more damage than trees without spheres. Orthogonal comparisons showed that the two treatments with sticky traps had significantly more damage than the other three treatments. Plots to evaluate organic controls for codling moths were established at the Horticultural Research Farm. Imidan treatments were applied as described previously. Surround and Sunspray UFO treatments were applied with an airblast sprayer at a spray volume of 100 gallons per acre. At harvest, 25 apples from each tree were inspected for the presence of codling moth damage. The organic treatments did not result in levels of codling moth damage that were significantly lower than in the untreated control. The Imidan treated trees had lower levels of codling

moth damage than the untreated control and both of the organic treatments. Studies to evaluate sulfur and copper for organic disease control were established in a block of scab free apples (RedFree) at the Horticultural Research Farm. Sulfur and copper treatments were compared with a standard fungicide program. However, disease pressure was extremely light and no differences in disease incidence were observed. Weeds in the organic plots were managed with weed mats and bark mulch.

b. *Impact* - These studies will help organic apply growers manage disease and insects with only organically certified products and techniques.

c. *Source of Federal Funds* - Hatch and USDA-NRI

d. *Scope of the Impact* - Multi-state

1.B. Genetic Resource Development

Key Theme: Apiculture

a. *Description* – Africanization of honey bees is a concern to growers and the general public. Scientists at Purdue University and in Mexico have identified a novel alarm pheromone from Africanized honey bees that is a derivative of the principal alarm pheromone. The combination of the two alarm pheromones had a synergistic effect on recruiting bees for colony defense. The guarding behavior in the colony entrance for Africanized honey bees is reinforced by the presence of large proportions of Africanized honey bees. However, European honey bees are not so affected. Normally 80 to 95 percent of the bees that stung were Africanized honey bees when co-fostered with European honey bees. But within ten seconds of the onset of stinging, Africanized honey bees recruited European honey bees and both types of bees were equally likely to sting. The quantitative trait locus (QTL) that represents a gene that influenced whole-colony stinging responses also influences individual guarding and stinging behaviors. Studies involving crosses between defensive and gentle European honey bees provide information on the role of guards and effects of specific genes. Not many of the guards stung during stinging assays, but removal of guards from the colony entrance reduced the stinging response. Three of these QTL influence individual's tendency to act as a guard. Nine new QTL that influence individual guarding behavior have been identified.

b. *Impact* - By probing the honey bee genomic DNA library and sequencing large clone candidates, the genes that influence honey bee stinging and guarding behaviors are being identified. This should lead to the selection and breeding of bees without the aggressive stinging behavior associated with the Africanized bees.

c. *Scope of Federal Funding* – Hatch, USDA-NRI and NSF

d. *Scope of Impact* - Multi-state and international

Key Theme: Animal Genomics

a. *Description* - The callipyge locus on chromosome 18 in sheep results in muscle fiber hypertrophy in the muscles of loin and pelvic limbs, but no significant hypertrophy in the muscles of the thoracic limbs. The callipyge animals also have reduced carcass fat. The callipyge phenotype is inherited in a non-Mendelian mode termed polar overdominance. In collaboration with Drs. Noelle Cockett (Utah State University) and Michel Georges (University of Liege, Belgium), Purdue University scientists are investigating gene expression in lambs with the callipyge trait. The callipyge region has been shown to contain an imprinted gene cluster with at least six expressed genes. The DLK1 gene is a well known growth factor and paternal expressed gene 11 (PEG11) has a putative protein-coding sequence that produces a paternally derived

sense strand transcript and maternally derived antisense strand transcripts (antiPEG11). The expression of PEG11 and antiPEG11 transcripts was analyzed using strand specific probes and northern blot analysis. Expression of a 6.5 kb PEG11 transcript was detected in muscles that become hypertrophied including the longissimus dorsi, semimembranosus and gluteus medius in 14-day, 56-day, and 84-day-old callipyge lambs . Expression analysis indicates that this chromosomal region is transcriptionally active during early development. Therefore, this locus will serve as a model for epigenetic regulation of early development in sheep.

b. *Impact* - The callipyge mutation is significant because it alters muscle and fat growth. Understanding how the mutation causes this will improve production in meat animals. The mutation occurs in a chromosome region that is regulated by parental imprinting which is often associated with genes involved in early development. The callipyge mutation also directly alters the expression of six genes over a large region of a chromosome so a better knowledge of the effect of the mutation will improve our understanding of how chromosomes function to regulate gene expression.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Multi-state

Key Theme: Biotechnology (1)

a. *Description* - The Hessian fly is the most important insect pest of wheat in the world. It is primarily controlled by the development of wheat cultivars that carry dominant Hessian fly resistance genes. Mutations in avirulence genes in Hessian fly permit this insect to survive and damage those genetically resistant wheat cultivars. Three avirulence genes were positioned on the chromosomes of the Hessian fly using genetic and physical mapping methods. Molecular genetic markers were genetically linked to avirulence genes and used to clone Hessian fly genomic DNA. The genomic clones were used as probes to position the avirulence genes on the chromosomes *in situ*.

b. *Impact* - This work clearly demonstrated that for each Hessian fly resistance gene in wheat, there is a single avirulence gene in the Hessian fly, facilitating the discovery of gene products that make wheat resistant to Hessian flies.

c. *Source of Federal Funds* – Hatch, USDA-NRI

d. *Scope of the Impact* - Multi-state

Key Theme: Biotechnology (2)

a. *Description* - During cell division, a regulatory protein known as Net1 controls both the activity of Cdc14 and its access to substrates. Throughout interphase and early mitosis, Net1 sequesters Cdc14 in the nucleolus and holds it in an inactive state until it is released as a fully active enzyme during late mitosis. To better define the mechanism by which Net1 inhibits Cdc14 Purdue University researchers have begun to map the regions in Cdc14 that mediate its interaction with Net1. They have used a reverse two-hybrid system and PCR-based mutagenesis to isolate point mutants of Cdc14 that fail to interact with Net1. Preliminary results of this work suggest that Cdc14 contains two potential Net1-binding regions, a segment near the N-terminus and sequences flanking its active site.

b. *Impact* - Efforts are underway to establish an alternative method to screen for Cdc14 mutants that fail to bind Net1. This screen will only yield mutants that are active and will serve to confirm the results of the two-hybrid screening procedure.

c. *Source of Federal Funds* – Hatch, NIH

d. *Scope of the Impact* - Multi-state and worldwide

Key Theme: Biotechnology (3)

a. *Description* - Glutathione S-transferases (GSTs) are encoded by a large gene family in plants where they can be divided into a number of classes. A number of Arabidopsis GSTs are induced by treatment with herbicide safeners, agrichemicals that are applied to cereal crops to protect them from herbicide damage. One of these, AtGSTU19, was identified by mass spectrometry of peptide fragments and shown to be a GST capable of conjugating chloroacetamide herbicides to glutathione. A variety of experiments indicate that AtGSTU19 is expressed primarily in roots both under controlled conditions and after safener treatment.

b. *Impact* - This knowledge should result in the development of safer and more effective herbicides for use in crop production.

c. *Source of Federal Funds* – Hatch, USDA-NRI

d. *Scope of the Impact* - Multi-state

Key Theme: New Uses for Agricultural Products

a. *Description* - Past work on sorghum grain nutritional quality resulted in identification of sorghum mutant lines with substantially higher protein digestibility than wild-type lines. Cooked flour starch digestibility is linked with protein digestibility, and the high protein digestibility mutant also has higher starch digestibility in cooked flour pastes comparable with maize or rice. Slow digesting, or slow glucose release, starches are an increasingly relevant research topic as fast digested starches are currently being linked to the high incidence of diabetes and obesity in the United States.

b. *Impact* - Creating ways to change the rate of starch digestion in foods could lead to slow glucose release starches that would be beneficial to diabetic and pre-diabetic populations, as well as apply to the growing obesity problem in the United States. High protein digestibility sorghum results in rapidly digested starch. This is important to population subgroups such as weaned infants in developing African countries.

c. *Source of Federal funds* - Hatch

d. *Scope of the Impact* - Multi-state and international

Key Theme: Plant Genomics (1)

a. *Description* - The plant cuticle represents a major barrier to the entry of agrochemicals into plants. Purdue University scientists have recovered mutant Arabidopsis plants in which the permeability of the cuticle to small molecules (such as herbicides) is increased. The goal of this research is to apply our understanding of cuticle biochemistry to improve the uptake of agrochemicals such as herbicides. A major effort has been devoted to cloning the genes that alter cuticle permeability. In addition to the fiddlehead (fdh) and hothead (hth) genes cloned previously, Purdue University researchers are very close to cloning deadhead (ded) and thunderhead (thd) genes. The ded gene maps very close to the centromere of chromosome 1 and also appears to be in different locations in different Arabidopsis genotypes. Relatively few genes are located in this region, but the region includes two acetyl-CoA carboxylase genes that could be involved in

producing the malonyl-CoA required by the enzyme encoded by fdh. The thd gene has been genetically mapped to a very small interval. Preliminary results have identified a cosmid clone that appears to complement thd mutations. If this result holds up, it would limit the molecular identity of thd to 4 to 5 genes.

b. *Impact* - Development of a non-destructive contact herbicide assay will allow the determination of the dose response of a single Arabidopsis plant to paraquat. Using this assay it has been shown that fdh mutants have greater sensitivity to paraquat than wild-type plants. This assay will be used as a genetic screen to identify new mutants with increased cuticle permeability.

c. *Source of Federal Funds* – Hatch, NSF

d. *Scope of the Impact* - Multi-state

Key Theme: Plant Genomics (2)
FY '02 Focus Area: Sustainability of Agriculture and Forestry

a. *Description* - Using 8-12 microsatellite markers, Purdue University scientists identified 111 full sib acorns from a naturally occurring cross between two adjacent trees on the Purdue University campus. This spring 101 acorns that produced seedlings were planted at a permanent site at the Horticulture Research Farm. When 20-30 good microsatellite markers are available, construction of the genetic map using this population of full sibs will be initiated. Purdue University researchers have examined 173 trees for chloroplast diversity. Samples were taken from 18 locations in Indiana, two from Pennsylvania, two from West Virginia, two from Illinois and one each from Minnesota and Wisconsin. Detection of chloroplast polymorphisms will permit the identification of regions of adaptation or seed zones for state tree nurseries in Indiana and in the Midwest. Using PCR-RFLP, five distinct haplotypes have been found. One of these haplotypes occurs only in older forests in southern Indiana. Purdue University scientists are conducting a detailed study of haplotype diversity at one old growth site in central Indiana at the Davis farm (a Purdue research farm) and one old growth site in southern Indiana (The Pioneer Mothers Memorial Forest). Three other species in the red oak subgenus have the same chloroplast haplotypes as those found in northern red oak. This suggests that interspecific hybridization in red oaks may be widespread and long standing.

b. *Impact* - These forested sites have belonged to Purdue University since 1916. The forest fragments have had the same boundaries since 1856 and have not been grazed or logged since 1916. This is a rich source of genetic information to select and produce faster growing hard woods for the U.S. furniture industry.

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

d. *Scope of the Impact* - Indiana

Key Theme: Plant Genomics (3)

a. *Description* -Four new chemically-induced sorghum mutants have altered synthesis of cuticle membrane. These mutants were all members of the bm2 allelic group, bm2-1, bm2-2, bm2-3, and bm2-4. Besides cuticle membrane reduction, these mutants (among all the bm mutants) had the greatest reduction in total cuticular wax amount and epicuticular wax crystalline density. As a means to clone these cuticle membrane genes, Purdue University scientists screened T-DNA mutagenized Arabidopsis populations to find four cuticle membrane mutants, mutants also having reduced waxes. These new sorghum and Arabidopsis cuticle membrane mutants are providing a valuable new resource for elucidating gene involvement in cuticle synthesis.

b. *Impact* - The results show that the sorghum bm mutants having altered cuticle membranes are more susceptible to fungal pathogens than all other bm mutants. To conserve our soil and groundwater resources, methods must be found to reduce the application of pesticides to urban landscapes and field crops. Recent work has revealed a strong physiological and genetic connection between plant cuticle and pathogen resistance. This research will be used with genetic engineering technologies to modify cuticular lipids on economically-important plants in ways that improve plant pest-resistance.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Multi-state

Key Theme: Plant Germplasm (1)

a. *Description* - Several quantitative trait loci (QTL) that condition resistance in wheat to *Fusarium* head blight and respective simple sequence repeat (SSR) DNA markers that are linked to the respective *Fusarium* head blight resistance QTL were identified in the three wheat lines, F201R, N894037, and Huapei 57-2. Wheat lines with combinations of these and other *Fusarium* head blight resistance QTL are being developed that are adapted to Indiana and the Eastern United States. Resistance to yellow dwarf viruses was transferred from intermediate wheatgrass to wheat. Wheat lines with this resistance show no or only very mild yellow dwarf viruses disease symptoms and show no yield reduction under severe natural yellow dwarf viruses infection, like in Indiana in 2002. Multiple genes that condition resistance against Hessian fly biotype L are being pyramided into advanced wheat lines to hopefully result in longer lasting resistance. Seed from two advanced wheat lines is being increased for release as commercial cultivars. One of the soft red winter wheat lines has genes H9 and H13 that condition resistance to biotype L, currently the most prevalent and virulent biotype in the Eastern United States. The second soft red winter wheat line being increased has yellow dwarf virus resistance from wheatgrass and intermediate resistance to *Fusarium* head blight.

b. *Impact* - Both wheat lines excel for yield potential and other agronomic performance traits, have excellent soft wheat milling and baking characteristics, and have resistance to glume blotch, leaf blotch, leaf rust, stem rust, stripe rust, powdery mildew, and soilborne mosaic virus.

c. *Source of Federal funds* - Hatch

d. *Scope of the Impact* - Multi-state

1.C. Plant Stress Management

Key Theme: Organic Agriculture
FY ’02 Focus Area: Organic Agriculture, Production, and Processing Methods

a. *Description* - This past year new funding permitted research on organically grown apples. New research plots were planted and preliminary pesticide trials using various ‘organic’ pesticides were conducted. Disease pressure was light to moderate; however initial results indicate that the major disease problems for organically grown apples in Indiana will be sooty blotch and flyspeck while plum curculio and San Jose scale will be major insect problems.

b. *Impact* - Organic production of apples in the Midwest is difficult because of the number and severity of pests. Also, the pesticides used to manage disease and insect pests are becoming increasingly scarce due to regulatory restrictions and the increasing occurrence of resistance. Thus, it is important that methods be

developed that allow growers to produce apples either organically or with less reliance on the broad-spectrum synthetic pesticides currently in use.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Midwest

Key Theme: Plant Genomics (1)

a. *Description* - Research focused on the identification of plant abiotic determinants of drought and salt stress tolerance. More than 210,000 Arabidopsis T-DNA insertion lines were screened to identify mutations that alter abiotic stress responsiveness. More than 100 stress responsive mutants were identified and more than 30 were linked to T-DNA insertions, where the mutation is the cause of the phenotype. Included in the list of abiotic stress adaptation determinants are ion and organic molecule transport proteins, kinases, phosphatases, transcription factors, and cell cycle and cytoskeleton regulators.

b. *Impact* - Abiotic and biotic stresses are major constraints to crop production in the United States and worldwide. This basic research with the Arabidopsis model plant will facilitate the development of the technology for gene delivery in bioengineered crops that are salt and drought tolerant.

c. *Source of Federal Funds* – Hatch, NSF

d. *Scope of the Impact* - United States and worldwide

Key Theme: Plant Genomics (2)
FY '02 Focus Area: Sustainability of Agriculture and Forestry

a. *Description* - Phosphate deficiency is a common occurrence all around the world. Plants have developed several adaptive mechanisms to survive under the deficiency. The objective of this research is to understand the molecular and genetic basis of phosphate starvation induced responses in plants. Mutants of Arabidopsis plants are used to express reporter genes under the regulation of phosphate starvation induced gene promoters. Transgenic Arabidopsis expressing the reporter genes under the regulation of phosphate transporter promoters have provided interesting data on phosphate starvation induced gene expression, involvement of hormones in gene regulation and spatial specificity of expression. Mutants generated by EMS and T-DNA gene tag techniques are being screened for altered response to phosphate starvation or sufficiency. Several putative mutants showing distinct phenotype and altered expression of the reporter genes have been isolated. The T-DNA activation tagged genes are being identified by the technique of TAIL-PCR or plasmid rescue techniques.

b. *Impact* - Phosphorus is one of the least available, but most important plant nutrients. A better understanding of how plants respond to phosphorus deficiency will facilitate development strategies to generate phosphorus efficient plants in the future.

c. *Source of Federal Funds* - Hatch and USDA-NRI

d. *Scope of the Impact* - United States and worldwide

Key Theme: Plant Production Efficiency (1)

a. *Description* - There is an inverse relationship between cultural practices that influence the availability of manganese and severity of several soilborne diseases. Take-all in wheat is increased under low manganese availability, and increased take-all has been reported following glyphosate applications. The wide-spread adoption of glyphosate tolerant soybeans, reported nutrient chelating ability of glyphosate, and sequential cropping of wheat following soybeans prompted this research. Initial increases in the population of manganese-oxidizing soil organisms observed in wheat rhizospheres following glyphosate treated soybeans was not definitive in later soil samplings. Glyphosate tolerant corn and soybean lines were 10-40% less efficient in manganese uptake than their normal counterparts on both the low and sufficient manganese soils. Growth and yield of glyphosate tolerant lines were significantly lower on a low manganese soil, but comparable on a manganese sufficient soil. Manganese amendments applied with the glyphosate (tank-mixed or sequentially) reduced the herbicidal efficacy of the glyphosate and were not as efficiently absorbed by the plant as applications made separately a week apart.

b. *Impact* - Manganese is a critical micronutrient for plant growth and disease resistance. Manganese deficiency reduces soybean yields in Indiana and requires annual foliar applications of this essential mineral for optimum yield and quality. Lower than normal rainfall in much of Indiana in 2002 exacerbated manganese deficiency symptoms in soybeans and resulted in reduced yields. Glyphosate-resistant soybean cultivars differ significantly in manganese efficiency and the severity of deficiency symptoms on low manganese soils. Manganese efficient varieties should be selected for planting in order to optimize production potential. Amelioration of deficiency symptoms by foliar application of manganese was least effective when manganese was tank mixed with the glyphosate.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Indiana

Key Theme: Plant Production Efficiency (2)
FY '02 Focus Area: Improved Pest Control and Food Quality and Protection Act Implementation

a. *Description* - Studies were continued to evaluate alternatives to the organophosphate insecticides that constitute the primary insect controls in apples. Several insect growth regulators and a fermentation product showed considerable promise for control of codling moth. A kaolin clay material (Surround) shows promise for control of plum curculio, but is not effective against codling moth. A pesticide use survey examined the extent to which Indiana apple growers have switched to alternative pesticides. A new acaricide, bifenzate (Acramite) was evaluated in commercial orchards and found to provide control of European red mite that is comparable to that achieved with the standard rescue acaricide (Pyramite) with less harmful effects on predator mites (Amblyseius fallacis).

b. *Impact* - Alternatives to organophosphate insecticides will allow apple growers to use less toxic insecticides.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Indiana

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

Key Theme: Animal Genomics

a. *Description* - Production of an F2 resource population was a means to identify the quantitative trait loci (QTL) influencing osteoporosis and other economically important traits in chickens. Grandparents of the population included 6 roosters from a commercial broiler line (Cobb) and 17 White Leghorn layer hens. An F1 generation produced from these grandparents, and production of approximately 500 F2 female offspring is underway. Genomic DNA has been extracted from all grandparent and F1 individuals, and microsatellite markers are currently being evaluated in the grandparents to identify markers that will be informative for a complete genome scan. Bone mineral density has been measured by densitometry in hens representing the broiler and layer lines used to generate the resource population. Densitometric scans were conducted on live, unanesthetized females from 15 to 65 weeks of age at 10 week intervals using a Norland pDexa X-ray bone densitometer. An analysis of covariance, using body weight as a covariate, was carried out to compare bone mineral density between the layer and broiler lines. The bone mineral density of the tibia of both the layer and broiler lines increased from 15 to 65 weeks of age, with the bone mineral density of the broiler increasing at a greater rate. The bone mineral density of broiler hens was significantly greater than that of layer hens at 35 weeks of age and older.

b. *Impact* - There appears to be a significant difference in the bone mineral density phenotype between the lines used as grandparents for the resource population. This variation will facilitate the identification of quantitative trait loci (QTL) influencing bone mineral density and will make it possible to reduce the incidence of osteoporosis in chickens.

c. *Source of Federal Funds* - Hatch and USDA-NRI

d. *Scope of the Impact* - Multi-state

Key Theme: Animal Health (1)
FY '02 Focus Area: Scientific Basis for Optimal Health

a. *Description* - Infectious bursal virus is an important chicken disease. Two plasmids p/VP243-VE containing the large segment gene of infectious bursal disease virus variant E strain (VE) and p/VP243-STC containing the large segment gene of infectious bursal disease virus standard challenge strain (STC), were constructed as DNA vaccines. One-day-old chickens were intramuscularly injected with individual plasmid or both plasmids and subsequently, boosted two times at weekly interval. Chickens were challenged with STC or VE at 21 days old and sacrificed 10 days later. Chickens receiving p/VP243-STC had 100% protection when challenged with STC, but only 20% protection when challenged with VE. p/VP243-VE provided 90% protection against VE and 70% protection against STC. Chickens receiving both plasmids had 80% and 100% protection against VE and STC, respectively. The results indicate that chickens vaccinated with p/VP243-VE plasmid alone or both plasmids (p/VP243-VE and p/VP243-STC) can provide adequate protection for chickens against classical or variant infectious bursal disease virus infection.

b. *Impact* - DNA vaccination is a potential new alternative approach for vaccination against infectious bursal disease in chickens. This should have a significant impact on the productivity and revenue of the U.S. poultry industry.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Multi-state

Key Theme: Animal Health (2)

a. *Description* - An *in vitro* assay for vitamin K epoxide reductase activity was developed and validated for swine hepatic microsomes. It was hypothesized that vitamin K epoxide reductase activity is inhibited by the agent which causes porcine hemorrhagic syndrome. Small quantities of extracts from feed and the livers of pigs with bleeding disorders were analyzed, and found that they do inhibit vitamin K epoxide reductase.

b. *Impact* - The information gained from this study will allow the swine industry to prevent the occurrence of porcine hemorrhagic syndrome and eliminate the need to supplement swine feed with vitamin K.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Multi-state

Key Theme: Animal Health (3)
FY '02 Focus Area: Scientific Basis for Optimal Health

a. *Description* - Therapeutic levels of antibiotics are commonly used in livestock feed. An experiment was conducted to evaluate the effect of antibiotics on the severity of gastric lesions in market age pigs. One hundred twenty, 9-week old crossbred pigs with an average weight of 43 pounds were used in the study. The experimental design consisted of a randomized complete block design with four experimental treatments. Treatments consisted of a non-medicated control diet, LINCOMIX fed at 200 g/ton for three weeks, Neomix fed at 300 g/ton for three weeks or LINCOMIX fed at 40 g/ton for the entire study. Nursery diets of pigs used in the study were deprived of all medications prior to initiation of the study. Pigs were housed in a continuous flow grow/finish facility for the duration of the study. Stomachs were collected at slaughter, evaluated for the presence of pathologic changes and scored based on a system developed in a Purdue University laboratory. Biopsies of gastric tissue were collected for microbiological analysis at an outside laboratory. Data analysis was based on individual animal performance criteria (growth and stomach scores). Supplementation of the diet with antibiotics resulted in a significant improvement in pars esophagea score.

b. *Impact* - Numerous bacteria have been incriminated in the causation of gastric ulcers in pigs with little agreement on the significance of those identified with the condition. This study characterized the bacteria of the porcine stomach that may precipitate gastric ulcers. Characterization of the bacteria of the porcine stomach explains the potential beneficial effects of feed-grade antibiotics on gastric health.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Multi-state

Key Theme: Animal Production Efficiency (1)

a. *Description* - Management and nutrition of the dairy cow during the 6-week interval around calving greatly impacts animal health, milk production in the ensuing lactation, overall longevity, and animal well-being. There is a paucity of information on the molecular adaptations during this interval, particularly the changes needed to support increased demands for gluconeogenesis. Pyruvate carboxylase, a key enzyme in glucose synthesis in liver, is up regulated in response to the onset of calving. Variant forms of the mRNA for bovine pyruvate carboxylase are expressed in liver. The physiological role of these variants has not been determined for bovine. Experiments have been completed to determine the

effects of energy restriction imposed 14 days prior to expected calving or the effects of force feeding during the same interval on postpartum feed intake, lactation performance and gene expression in liver. Cows that were feed-restricted produced less milk and consumed less feed post-calving than either control or force-fed. Forced-fed cows tended to consume less fed postpartum and produce less milk than control cows. Supporting data indicate that feed restriction during lactation increased pyruvate carboxylase expression whereas expression of phosphoenolpyruvate carboxykinase, another potential pace setting enzyme for gluconeogenesis, was unchanged.

b. *Impact* - Hypoglycemia, ketosis, and related metabolic disorders occur when dairy cows fail to adapt to the increased metabolic demands of lactation. These disorders represent a significant income loss to the dairy industry and are closely linked to an inability of liver to synthesize glucose to support mammary metabolism. Understanding of the molecular adaptations of glucose metabolism in liver during the transition to lactation will be used to develop a model of metabolic transitioning to lactation during normal and aberrant states and to devise appropriate therapies.

c. *Source of Federal Funds* - Hatch and USDA-NRI

d. *Scope of the Impact* - Multi-state

Key Theme: Animal Production Efficiency (3)

a. *Description* - Egg yolk has four times the concentration of immune globulin found in chicken serum. Pasteurized spray-dried egg made from fresh, unfertilized eggs with shell removed provides an amino acid (lysine = 3.72%), fat (28%), immune globulin rich ingredient for segregated early weaned pigs. The addition of 5% spray-dried egg to a standard starter diet containing 15% dried whey significantly increased rate of gain and feed intake of segregated early weaned pigs. Diets for weaned pigs containing porcine plasma protein (also rich in immune globulin) or spray-dried egg at 5% of the diet supported similar gain and efficiency values. When lactose and spray-dried egg were incremented into diets for segregated early weaned pigs at a constant ratio of 3:1, gain, intake, and efficiency were improved as the combination was titrated up through 16% of the diet with no further benefit from higher inclusion levels.

b. *Impact* - The spray-dry process enables egg producers to add value to inedible, undergrade, or low-value eggs by producing a feed ingredient of extremely high nutritional and immune globulin value for young pigs. This process also removes a potential biohazard from the environment.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Multi-state

Key Theme: Agricultural Production Efficiency (4)

a. *Description* - An in-house manure turning machine was analyzed in a commercial high-rise caged pullet operation. The machine turned manure 2-3 times per week. Observations were made of adult house fly abundance in the pits, house fly larval activity, and litter beetle and beneficial insect activity. Comparisons were made with 10 houses with in-house undisturbed manure accumulations. In houses where the manure turning machine was used, significant reductions were observed in house fly breeding, adult house fly numbers and in litter beetle and beneficial insect populations.

b. *Impact* - New manure handling technologies will alter the environment where house flies breed, reduce the adverse impact of flies in poultry production, reduce operating costs, and reduce environmental nuisance concerns of fly activity.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Multi-state

Key Theme: Bioterrorism
FY '02 Focus Area: Scientific Basis for Optimal Health

a. *Description* - Biosecurity procedures to prevent the potential transmission of strains of foot-and-mouth disease virus from the United Kingdom by emergency responders were tested in a collaborative project between Purdue University and Plum Island Animal Disease Center. Showering and donning clean outerwear was necessary to prevent transmission to both pigs and sheep. Elimination of downtimes could decrease the number of essential personnel needed to contain an outbreak because personnel could move more efficiently from farm to farm. Biosecurity procedures to prevent transmission of *E. coli* by people were tested in a collaborative project between Purdue University and Iowa State University. Again, showering and donning clean outerwear was necessary to prevent an animal caretaker from transmitting *E. coli* from sick pigs to healthy sentinel pigs. These results will assist pork producers in developing farm specific biosecurity protocols.

b. *Impact* - Purdue University veterinary researchers determined effective protocols to prevent human transmission of porcine reproductive and respiratory syndrome virus, transmissible gastroenteritis virus, *E. coli* and foot and mouth disease virus. These protocols can be used daily on farms. They can accelerate containment of exotic disease outbreaks, such as foot and mouth disease. A public website to assist the public in developing biosecurity protocols was developed. In conjunction with the National Pork Board's Homeland Security initiative, guidelines were developed. A National Biosecurity Resource Center was established to provide scientifically sound biosecurity procedures to protect the health of the nation's livestock that are at risk from economically devastating disease outbreaks.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - United States and worldwide

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

Key Theme: Agricultural Competitiveness (1)

a. *Description* - Five methods of quantitative measurement of the monopoly overcharge generated by effective cartels were illustrated with data from the 1992-1995 global lysine conspiracy. These methods vary in the degree of data detail required and the extent to which they are likely to be accepted by courts for awarding legal damages to plaintiffs. About 40 global cartels prosecuted by U.S. or EU antitrust authorities since 1995 were surveyed. About 85% of the cartel activity was concentrated in markets for food or feed ingredients. On average, cartels were successful in raising selling prices by 24%.

b. *Impact* - The financial costs incurred by cartels (fines and settlements to private plaintiffs) reveals that in only one of 16 cases examined did these costs exceed global monopoly profits made by the cartels. Analysis of the *ex ante* decision to join these types of cartels shows that present-day fine structures are wholly inadequate to deter cartel formation. In some cases, fines as high as 60 times expected cartel profits may be necessary for absolute deterrence.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - United States and worldwide

Key Theme: Agricultural Competitiveness (3)

a. *Description* - A study of consumer perceptions of the fat content of meat found that there are considerable discrepancies between consumers' beliefs and the actual fat content of various meats. Generally, consumers think meat contains more fat than it actually does with the discrepancy being largest for pork.

b. *Impact* - Survey results suggest a need for consumer nutrition education programs offered by nutritionists and/or industry groups to improve consumers' perceptions of the actual fat content in meat, especially pork given the recent changes in swine genetics and rations, to help them make more informed nutritional choices which should improve consumer health and welfare.

c. *Source of Federal Funds* – Hatch

d. *Scope of the Impact* – United States

Key Theme: Agricultural Competitiveness (4)

a. *Description* - Poverty reduction is an increasingly important consideration in the deliberations over multilateral trade liberalization. However, studies of multi-country, global trade liberalization have had little to say about this. A methodology for combining national household survey data with results from international economic modeling was developed to assess the linkages between multilateral trade policies and poverty. The model results suggest that trade liberalization reduces poverty in Indonesia, Philippines, Thailand, Uganda, and Zambia, while it is increased in Brazil and Chile. Liberalization leads to a reduction in poverty among the agriculture-specialized households in all the focus economies. However, the socioeconomic impact on other poor households is mixed

b. *Impact* - Global Trade Analysis Project (GTAP) has become the common "language" for economists worldwide working on the empirical assessments of trade agreements. It is used by more than 1500 researchers in more than 90 countries (http://www.gtap.agecon.purdue.edu). GTAP-based results have recently been featured in major publications assessing the impact of global and regional trade agreements by the leading international organizations, including: FAO, IMF, World Bank and OECD. It is also heavily used by agencies of the U.S. government, including the Economic Research Service/USDA, the International Trade Commission and the U.S. Environmental Protection Agency.

c. *Source of Federal Funds* - Hatch and USDA-NRI

d. *Scope of the Impact* - United States and worldwide

Key Theme: Agricultural Competitiveness (5)

a. *Description* - An outbreak of foot-and-mouth disease could significantly impact international trade in livestock products. The impacts of a potential foot-and-mouth disease outbreak in the United States were decomposed into three effects: 1) the removal of livestock from the market, 2) a loss of meat exports, and 3) adverse consumer reaction to eating meat following a foot-and-mouth disease outbreak.

b. *Impact* - Simulation model results indicated a loss in farm revenue of $14 billion from a potential foot-and-mouth disease outbreak in the United States of which $6 billion would came from a loss in export sales of meat.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - United States and worldwide

Key Theme: Agricultural Profitability

a. *Description* - This project explored methods to improve decision making by agribusiness firms. A series of surveys of retail dealers provided important insights into the adoption of precision agriculture technologies by these firms. In general, there has been a slow, but steady, adoption of precision technologies by retail dealers. Dealers focused most heavily on site-specific services such as field mapping that do not require large capital outlays. Offerings of services that are more capital intensive such as controller-driven variable rate application were slower to materialize, but modest growth did occur. Provision of these services was higher in the Midwest relative to other states, and more prevalent in cooperatives and larger national organizations relative to independent operations. Overall, agricultural input firms are quite bullish on the prospects for e-business. Survey respondents identified lower prices, ease of access to information, and more product choices as the primary catalysts for e-business adoption, while challenges delivering after sale service, security concerns, and privacy concerns were the primary barriers to expansion of e-business. Retail dealers believe seed and service sales would increase, fertilizer sales would not change, and chemical sales would fall with the net result that overall profits would be unchanged.

b. *Impact* - This study provides the only publicly available data that benchmarks the adoption of precision agricultural services by retail agronomy dealers. These data are being widely used to help dealers manage the introduction of precision agricultural services. E-business is a relatively recent, but rapidly expanding, way of doing business in the agricultural industries. This research provided a look at the state of the industry, and insight into the e-business plans of U.S. agribusiness firms. Such information is highly useful to firms considering investment decisions in e-business technology.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - United States

Key Theme: Risk Management

a. *Description* - Crop insurance, pre-harvest marketing and combination insurance/marketing strategies were evaluated for those years following a normal crop year (1989, 1992, 1994 and 1996 were excluded as years following a short crop year) in the 1986 to 2000 period. Results were generated by a stochastic simulation model of a farm with a 50/50 corn-soybean rotation with yield variability based on Federal crop insurance farm level data for Carroll County, Indiana. Mean revenue and downside risk, measured by the 5% value-at-risk, were used to evaluate risk management strategies against a benchmark of cash sales at harvest. Costs and returns associated with risk management such as insurance premiums, options premiums, interest foregone on margin accounts, insurance indemnities and marketing gains or losses were accounted for in each strategy

b. *Impact* - The pre-harvest marketing strategy with the highest average returns, $287.47 per acre, was only about $6.20 or 2.5% above the cash sales at harvest benchmark. Of the ten marketing strategies with the highest average revenues, six had 5% value at risk values lower than the benchmark, indicating more downside risk. Insurance strategies resulted in 5% value at risk values about 20% above the case sale benchmark with little or no decrease in average revenue. Several combinations of insurance with pre-harvest marketing strategies resulted in higher mean returns and less downside risk than the cash sale at harvest benchmark. High ranking strategies typically involved early spring sale of part of expected production but included a variety of insurance products.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Indiana

1.F. Value-Added

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

a. *Description* - How value-added grains might effect production and marketing decisions by farmers, elevators, and end-users in the grain marketing and coordination system was studied. Various types of coordinated systems being used for high-oil corn, and the impact on all participants in the value-chain, including producers, elevators, and end-users were assessed. Differences in yield and quality attributes of high-oil corn in terms of means, variability, and end-use characteristics, relative to conventional hybrids were analyzed. Finally, the farm-level risk and profitability of high-oil corn production was determined under alternative high-oil corn marketing systems.

b. *Impact* - High-oil corn sold under export market and/or domestic contracts may be a viable option for producers if premium structures remain intact or yield deficiencies are improved. High-oil corn for pork and poultry rations may be a valuable feed ingredient, but livestock producers may not be willing to pay the premiums currently being provided by export and domestic market contractors. Evaluation of alternative supply chains for high-oil corn indicates that the most likely long-term markets for high-oil corn will be on farm feeding and local direct delivery to livestock producers. Livestock feeders are not willing to pay high premiums for high-oil corn when the key value trait (oil) is so variable.

c. *Source of Federal Funds* - Hatch and USDA-NRI

d. *Scope of the Impact* - Multi-state

Key Theme: Adding Value to New and Old Agricultural Products (2)

a. *Description* - Fruits and vegetables grown in the United states account for approximately 25% of the crop cash receipts, while occupying only about 2.5% of the crop acreage. It is highly desirable, if not essential, that their quality be maintained from the time of harvest through the time of consumption. Soluble solids content is an important quality attribute for many fruits and vegetables because it affects sweetness and therefore influences consumer satisfaction. Fruits and vegetables with internal defects are of little or no use to the consumer. Nondestructive detection of either of these attributes during packing or receiving operations would reduce losses and increase customer satisfaction by allowing lower quality and defective fruits and vegetables to be removed close to the point of production and diverted to alternative uses. This study explored the use of magnetic resonance diffusion measurements for nondestructive measurement of soluble solids of fruits, vegetables, or fruit juices.

b. *Impact* - Based on this study, magnetic resonance detection of internal damage such as water core and internal browning in apples, which is simpler than soluble solids measurement, would be feasible for on-line sorting operations if the time required for detection could be reduced from two seconds to a fraction of a second.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - United States

Key Theme: Adding Value to New and Old Agricultural Products (3)

a. *Description* - The native milk enzyme plasmin is a protease that breaks down the milk protein casein. This enzyme has been shown to reduce the time needed to ripen cheese, which would have enormous economic benefits for cheese manufacturers. Plasmin exists predominantly in fresh milk in its inactive form, plasminogen, which is converted to active plasmin by other native milk enzymes called plasminogen activators. However, there is disagreement in the literature regarding the nature of these plasminogen activators in milk. Research results suggest that plasmin-system activities were highest in milk from cows with two or three offspring, and were lower in cheese curd than in casein pellets. This suggests that plasmin activity in cheese curd can be increased by selecting milk from cows with two or three offspring to be used in cheese production. Secondly, plasmin activity in cheese curd can be increased by limited heat treatment of casein micelles.

b. *Impact* - Characterization of the plasmin system in milk can help increase the level of active plasmin in cheese, which can reduce the time for cheese ripening and provide economic gain for cheese processors.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - United States

Key Theme: New Uses for Agricultural Products (1)

a. *Description* - Soybean proteins, in combination with carbohydrate gels, have led to the development of gelatin dessert substitutes. By eliminating animal gelatin proteins, some consumer concerns involving animal derived products have been eliminated, as well as enhancing nutritional benefits by incorporating soybean isoflavones in the product. This soy-based gelatin product is currently being commercialized by a specialty food company.

b. *Impact* - The development of new soy-based food products such as gelatin desserts can create new markets for U.S. soybeans.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - United States

Key Theme: New Uses for Agricultural Products (2)

a. *Description* - Purdue University researchers have developed modified starch products with novel or improved properties using already approved reagents at allowable levels. 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. In connection with the analysis required for this

research Purdue University scientists needed to know the extent of leaching from derivatized starch granules, so aqueous leaching of hydroxypropylated common corn starches at different times and temperatures was conducted. Results indicated that the greater the modification, the easier it was for the amylose to leach out and the preference for leaching of derivatized amylose decreased.

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 by them, the only way to produce starch products with improved or novel properties is through a more thorough understanding of the natures of starch granules and the relationship between granule structure and behavior. Knowledge gained form this project provides another step in the development of strategies to control and/or to modify the sites of reaction in starch granules. Researchers were able to make modified food starch using only natural products and without waste effluent. This treatment will produce modified starch in an environmentally friendly way.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - United States

GOAL 2: SAFE AND SECURE FOOD AND FIBER SYSTEM

Overview: The safety of our food supply continues to present significant challenges. The Center for Disease Control and Prevention estimates that 76 million cases of foodborne illness, 325,000 hospitalizations, 5500 deaths, and costs of $7.7-$23 billion occur each year in the United States. One of the important keys for preventing foodborne illness is through effective measures to detect and reduce the risk of contaminant presence, survival, and growth. Pathogens, such as *Listeria monocytogenes* and *Escherichia coli* O157:H7, have been targets for detection and prevention due to their low infective dose, dangerous disease characteristics, and widespread occurrence in foods. In addition to contaminant detection systems, better strategies for contamination protection and pathogen reduction are also being developed. Much of the research focus related to food safety has been dedicated to addressing multi-state (or national) needs that also have international implications. Quality improvement programs have also been developed mainly to address needs for grain, plant and animal products. Food safety and quality research programs at Purdue University range from concentrated efforts of research teams across many schools (e.g., pathogen detection effort) to very focused efforts that address specific state and national needs (e.g., improved pork quality).

Successes:

- Developed specific pathogen detection systems, using a multi-discipline research team approach, for *Listeria monocytogenes* that are rapid, accurate, and can be applied in many facets of the food industry.
- Developed antibodies against mycotoxin producing molds important to the grain industry that were further used to develop mold detection systems.
- Adopted a scatterometer for bacterial detection system that can be used to detect an array of bacterial pathogens simultaneously in foods.
- Established a kinetic model to describe inactivation of important foodborne pathogens (e.g., *Listeria monocytogenes)* in ready-to-eat processed meats.
- Developed and validated lower cost, rapid assay for measurement of PCBs in fish tissue.
- Developed a novel non-thermal processing system, using chlorine dioxide gas, for the inactivation of pathogens in fruit and vegetable products.
- Determined the usefulness of using color machine vision technology for assessing the quality of pork products.

- Evaluated the efficacy of ozone as a fumigant to control pests in stored grain.
- Developed a method to evaluate the effect of food handling practices during transport and delivery of home delivered meals to older Americans.

Benefits:

- The development of bacterial pathogen detection methods, that are more accurate and more rapid, will allow food processors and food regulatory agencies to identify potential problems more quickly, thus reducing the risk of food contamination and foodborne illness.
- The development of detection systems for molds, especially for mycotoxin-producing molds, that are more accurate and more rapid, will allow food processors and food regulatory agencies to identify potential food safety and food quality problems more quickly. This, in turn, will help reduce the risk of food contamination and foodborne illness as well as strengthen food quality.
- The development of a rapid assay for PCB's in fish tissues will help states as they determine and issue fish advisories and warnings for consumers.
- Pork quality and grading tasks can be performed more rapidly and more accurately with color vision technology.
- Grain storage conditions can be improved to deliver better quality grains to processors and consumers and new technologies can be used to effectively reduce the risk of mycotoxin production.

Key Theme: Food Handling

a. *Description* - Four questionnaires (two for meal providers, one for drivers, and one for home delivered meal recipients) were developed and pilot tested to assess food handling, storage, and delivery of home delivered meals to older Americans. Three hundred meal providers, 1500 consumers, and 150 drivers were surveyed. Using information from the surveys, tests will be conducted in year two of the study to determine the affect of typical handling, storage, and delivery practices on temperature and microbial content of sample meals. From this information, instruction/educational guides will then be developed for meal providers, drivers, and consumers to promote safe handling of home delivered meals that have participated in the study.

b. *Impact* - The potential impact of this project is for older Americans to receive safer home-delivered meals. Information provided through this project should improve the safety of these meals and decrease the potential for foodborne illness. Home-delivered meal providers will also benefit by being able to make better food preparation/budgeting/equipment decisions.

c. *Source of Federal Funding* - Hatch

d. *Scope of Impact* - Multi-State

Key Theme: Food Security (1)

a. *Description* - Since September 11, 2001, there has been a heightened concern over food biosecurity from harmful agents that could pose a threat to plant and animal systems and ultimately to the food supply. There is an imminent need for improved systems for detection of microbial and chemical contamination in foods. Current available detection systems are neither sensitive nor accurate enough, are costly, involve many days for contaminant identification, and are not easily usable for the industry or regulatory agencies. Scientists at Purdue University have combined engineering technologies and food safety expertise to find solutions to these problems. The Center for Food Safety Engineering is a newly formed center at Purdue University operating through the Office of Agricultural Research Programs. The Center

is developing better methods for hazard detection and better ways to control hazards in our food system. Research teams are composed of scientists from five different schools including agriculture, consumer and family sciences, engineering, science, and veterinary sciences. Engineers and food microbiologists are working on developing postage-sized biochips to detect pathogens more quickly and more accurately. Animal scientists, food scientists, and microbiologists are working on developing a post-pasteurization procedure to reduce the risk of *Listeria monocytogenes* contamination in ready-to-eat luncheon meats. Plant pathologists and food mycologists are developing rapid screening methods for mold identification and isolation that will help in grain storage and food processing operations.

b. *Impact* - There has been a wide variety of impacts that have been produced by multi-disciplinary team researchers. They have:
   - Developed techniques for amplification of organisms from foods using culture or rapid separation techniques, and selective capture of pathogenic organisms from a complex background of other organisms, protein macromolecules, and other food substances.
   - Developed an interdigitated microsensor electrode-chip based cytotoxicity assay (cell-based sensor) for detection of *Listeria monocytogenes* from food.
   - Developed antibodies against *Fusarium graminearum* and *Fusarium verticillioides* to produce an indirect ELISA (enzyme-linked immunosorbent assay) to detect these molds in foods.
   - Adopted a scatterometer for bacterial detection in foods.
   - Constructed bioluminescent reporter strain for acyl-homoserine lactone detection and evaluated its performance characteristics.
   - Established a kinetic model to describe inactivation of *Listeria monocytogenes* in ready-to-eat luncheon meats.
   - Developed and validated a lower cost, rapid assay for the measurement of PCBs in fish tissue.

   The development of bacterial pathogen detection methods that are more accurate and more rapid, will allow food processors and food regulatory agencies to identify potential problems more quickly, and, thus reduce the risk of food contamination and foodborne illness. The development of detection systems for molds, especially for mycotoxin-producing molds, that are more accurate and more rapid, will allow food processors and food regulatory agencies to identify potential food safety and food quality problems more quickly. This, in turn, will help reduce the risk of food contamination and foodborne illness as well as strengthen food quality. The development of a rapid assay for PCB's in fish tissues will help state regulatory agencies determine and issue fish advisories and warnings to consumers of wildish catches.

c. *Source of Federal Funding* - Hatch and USDA-ARS

d. *Scope of Impact* - Multi-State and International

Key Theme: Food Security (2)

a. *Description* - Spores of *Bacillus anthracis* (agent of anthrax) have been identified as a potential and likely threat of bioterrorism to humans or foods. Chlorine dioxide gas has been proposed as a possible means of disinfection, however, little is known relative to efficacy of *Bacillus* spores. A study examined chlorine dioxide as a disinfection agent on the inactivation of *Bacillus* spores on different surfaces, such as envelope paper, wood, and plastic. Approximately 1 million cfu/surface *Bacillus thuringenisis* spores (a surrogate for *Bacillus anthracis*) on paper, wood, epoxy and plastic surfaces could be inactivated by 5 to 30 mg/l chlorine dioxide gas treatment for 12 hours under 85-92% relative humidity and at 22±1C. The minimum chlorine dioxide gas concentration to completely inactivate the 6 log inoculated spores was 30 mg/l for paper and wood surfaces, 25 mg/l for epoxy surfaces, and 20 mg/l for plastic surfaces.

b. *Impact* - These results will be very useful in providing insight into parameters for effective decontamination procedures for *Bacillus* spores. This could be a very significant form of detection/protection of human health and food contamination.

c. *Source of Federal Funding* - Hatch

e. *Scope of Impact* - United States and international

Key Theme: Foodborne Pathogen Protection (1)
FY '02 Focus Area: Scientific Basis for Optimal Health

a. *Description* - The efficacy of a non-thermal means of processing using chlorine dioxide gas in inactivating *Escherichia coli* O157:H7 or *Listeria monocytogenes* on different apple surfaces was investigated. After optimizing treatments, more than 1,000-fold reductions in pathogens on the surfaces of apples were found. Under certain conditions, pathogen reduction was greater than one billion-fold. The Food and Drug Administration has been seeking processes that result in a 100,000-fold reduction in juice pathogens.

b. *Impact* - Due to the health benefits associated with fruit and vegetables, people are eating more raw produce today than ever before, and at the same time, more foodborne outbreaks have been attributed to raw fruit and vegetable products. In response to these concerns and consumer demand, alternative microbial reduction strategies are needed, especially in food processing operations. Chlorine dioxide gas is a good example of a promising technology that can be used to reduce pathogens in produce. Understanding and developing alternative methods for non-thermal processing will aid in the production of safer and higher quality fruit and vegetable foods.

c. *Source of Federal Funding* - FDA

d. *Scope of Impact* - Multi-State

Key Theme: Foodborne Pathogen Protection (2)

a. *Description* - The time of calving has many stressors for first-calf heifers. Prepartum milking and adaptation to the milking parlor of first lactation heifers were examined for effect on udder health, milk production, and reproduction throughout the first lactation. Intensive data collection on pre-milked and control heifers shows that calving parameters were not significantly affected by pre-milking. However, pre-milking decreased udder edema and blood plasma haptoglobin levels (a measure of tissue inflammation), but did slightly increase the presence of any mastitis causing bacteria after calving.

b. *Impact* - Prepartum milking of heifers may decrease udder edema, reduce somatic cells in milk, and lessen the risk of displaced abomasums without reducing the fertility of dairy heifers following initial calving. Reduced health disorders and sustained milk production means that milking heifers prior to calving could allow reduction in the number of groups of heifers that must be managed separately on grazing or conventional dairy farms. Infrared images show potential for detection of skin surface temperature that may be related to inflammation due to mastitis.

c. *Source of Federal Funding* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Food Quality (1)

a. *Description* - The quality of fresh pork plays a major role in capturing financially lucrative markets. Export markets demand uniformity, a bright pink color and a high water binding capacity. The ability to sort for these demand factors, as well as to get pork quality assessment in a timely fashion to allow reporting back to the on-farm sector where genetics and management play a key role in meat quality, would be a major breakthrough for the industry. While near infrared spectroscopy seems to offer some potential for early detection of quality problems, the apparent presence of genetic bias associated with the near infrared spectroscopy techniques studied prevent the development of robust predictive techniques that can be used across the industry. Emphasis in this project has shifted to the development of a simple technique for determining moisture release for muscle, at any given time post-mortem. Water absorbed by an implanted absorptive material has the ability to measure the amount of water escaping from muscle and other meat tissues. Research is being conducted to determine when, where and for how long the material should be implanted in order to most accurately determine the amount of moisture released. Electrical stimulation of carcasses immediately after exsanguination tends to produce a low water holding capacity and the associated high drip loss from fresh meat. Electrically stimulated carcasses were compared with normal carcasses to assess the ability of the technique to measure moisture released from muscle.

b. *Impact* - Color machine vision can be used to accurately and rapidly sort fresh pork cuts into the six National Pork Producer Council (NPPC) pork color classes. Current research provides the groundwork for development of techniques for predicting meat quality in the early post-mortem period before all of the quality characteristics are fully developed. As new basic information on the biological mechanisms associated with the development of pale color and/or high drip loss in pork becomes available, future research will use information generated by this project as a starting point in developing a new technology.

c. *Source of Federal Funding* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Food Quality (2)

a. *Description* - Primary research goals focus on the quality of cereals and oilseeds during handling, storage and transport by assessing the effects of post-harvest practices on microbial growth, insect infestation, chemical usage, drying, handling, and processing. One option is enlarging the receiving pit holding capacity and dimensions to increase the throughput of the unloading operation for one of the grain elevators using a computer simulation model. Enlarging the pit size in order to simultaneously dump the two hoppers of a trailer carrying about 25 MT of grain without moving the semi truck back and forth would yield a 1.1 min/truck time saving for each load.

b. *Impact* - The results from this research will reduce the truck cycle time per load for farmers, which will increase their daily crop harvesting capacities without having to add additional transportation equipment. Consequently, the grain volume received at the elevator could be considerably higher with this modified configuration. This will help country elevators achieve greater efficiency, customer service, flexibility, and overall grain quality with respect to their grain unloading operations**.**

c. *Source of Federal Funding* - Hatch

d. *Scope of Impact* - Midwestern States

Key Theme: Food Quality (3)

a. *Description* - Work on the processing of cereal products has focused on obtaining a fundamental understanding of the effect of raw material properties on the granulation, sheeting, and expansion processes for the manufacture of cereal products. The primary objective was to develop a methodology to predict the granulation of starch/protein mixture in a high shear mixer based on the rheological properties of the raw material and the processing parameters. The calculated contact area increased with increases in applied pressure, temperature and moisture content. Rheological properties for dough at elevated temperatures while accounting for material changes due to starch gelatinization were measured.

b. *Impact* - Cereal processors and bakeries will be able to adjust their granulation, sheeting, and expansion process conditions to account for variations in raw material properties and therefore produce better quality products.

c. *Source of Federal Funding* - Hatch

d. *Scope of Impact* - Multi-State

Key Theme: Food Quality (4)

a. *Description* - It has been hypothesized that expression of AILP in maize kernels may slow colonization by *Aspergillus flavus* mold and reduce aflatoxin contamination. To test this hypothesis, Purdue University scientists are cloning the gene (LAI) encoding AILP, which will express LAI in *Escherichia coli* and maize. The goal is to identify a LAI gene that encodes an active a-amylase inhibitor prior to transforming the gene into maize.

b. *Impact* - Research on the regulation of aflatoxin biosynthesis will reveal vulnerable points in the pathway that can be targets for control by bioengineering techniques. The completion of the proposed objectives will yield important information about the role of an enzyme, a-amylase, in aflatoxin production and identify novel amylase inhibitors that are specific towards the *Aspergillus flavus* a-amylase. The information will impact agriculture by furthering our understanding of aflatoxin contamination of grains and by determining if inhibiting a-amylase is a feasible method for controlling aflatoxin production.

c. *Source of Federal Funding* - Hatch

c. *Scope of Impact* - Multi-State

Key Theme: Food Quality (5)

a. *Description* - The efficacy of ozone as a fumigant to control pests in stored grain was evaluated. Ozone is attractive because its metabolic product is oxygen, thus leaving no undesirable residue, and ozone can be generated on-site eliminating the need to store or dispose chemical containers. An apparent velocity of 0.03 m/s was optimal for achieving 85% of the ozone concentration from the ozone generator to a 2.7 m depth in 0.8 d. About 90% of the ozone concentration was reached in less than 0.5 d with an apparent velocity 0.02 m/s. These velocities are within the capability of standard aeration fans suggesting that ozone fumigations are achievable in maize. Treatment of grains with 50 ppm ozone for 30 days had no detrimental effect on popping volume of popcorn, fatty acid and amino acid composition of soybeans, wheat, and maize, milling characteristics of wheat and maize, baking characteristics of wheat, and stickiness of rice. These data indicate that, if repeated ozone fumigations are needed, such treatment should not decrease the quality of grain for end-users.

b. *Impact* - Once laboratory trials can be confirmed in the field, the behavior of Indian meal moth and native populations of beetles can be tested to determine if ozone can not only be used as a fumigant but also as a deterrent. Research completed to date provides information for grain handlers and food processors that will ultimately use ozone-treated grain. Future investigation is needed to determine the economics costs and benefits of implementing ozone technology into grain management practices.

c. *Source of Federal Funding* - Hatch

d. *Scope of Impact* - Multi-State

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, a deeper understanding of nutritionally affected metabolic pathways is essential. With this knowledge, better nutritional guidelines can be designed and new foods with improved or added benefits can be developed. To that end, Purdue University researchers have conducted basic nutritional biochemistry research, identified and quantified 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 to current diets. This work will lead to a healthier, better-informed public capable of making choices among a wide variety of nutritious and functional foods and dietary supplements.

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

Bone Health: Purdue University researchers have focused on both identifying and correcting deficiencies in essential nutrients as they relate to bone health. Continued strong research at Purdue University focuses both in the clinical area and the cell culture model. In the area of calcium metabolism, it was shown that African-American girls retain more calcium than Caucasian girls when fed the same calcium intakes. This accounts for the racial differences seen in adult bone mass and lower incidence of osteoporosis in African-Americans versus Caucasians. Black adolescent girls retained calcium significantly more efficiently than white girls through increased calcium absorption and higher bone formation relative to bone resorption rates and decreased urinary calcium losses. Researchers conducting *in vitro* cell culture research using bone osetoblasts showed this year that long-chain omega-3 polyunsaturated fatty acids can up regulate or increase osteoblast activity to support bone formation.

Carbohydrates in health: Purdue University scientists are using microarray technology to screen rat liver genes for changes resulting from various levels of dietary fiber. Thirty-five genes have undergone change that could modify cholesterol and bile acid metabolism, promising to decrease risk of chronic disease.

Reduction in caloric intake: Although many populations struggle with having enough to eat, in the United States over-nutrition to the point of obesity is a problem. Purdue University scientists are addressing two aspects of this issue:

(1) Researchers used inulin, a natural carbohydrate found in some plant roots, which has few calories and functions like a fiber, to replace sugar in corn muffins and a low-fat frozen dessert. Up to 15% and 40% of the

sugar in these food products, respectively, could be substituted with inulin without detectable changes in their sensory quality.

(2) Sensory and energy studies conducted at Purdue University have shown calorie-rich beverage intakes yield weak appetite suppression and may lead to positive energy balance. This research supports the theory that high-calorie beverage consumption may be contributing to the high level of overweight and obesity in the U.S.

Cancer prevention: Cancer is characterized by unregulated growth of cells that are resistant to programmed death. Researchers at Purdue University have shown that active vitamin D (1, 25 $(OH)_2D$) inhibits cell death in normal cells, but not mutated ras gene containing cells. Continued research on vitamin D and cell growth and death regulation is being pursued.

Vitamin A: A vitamin A-responsive protein on the cell membrane of HeLa cancer cells has recently been shown to determine the period length of a circadian biochemical marker functioning as the driver of the cellular biological clock.

Functional foods for health: Purdue University continues to conduct research in the area of natural compounds. Evidence was shown this year that tea and citrus juices, which are not nutrients, contribute antioxidant protection to the body. Data from a nutrition education program on functional foods suggests that individual consumers had a fairly positive view of functional foods and tried to eat more servings of some popular functional foods.

Successes:

- Genes associated with coronary heart disease and colon cancer that respond to dietary fiber were identified.
- Inulin, a natural carbohydrate found in the roots of some plants, has fewer calories than sugar and reduces blood lipids and cholesterol, was tested in pastries and desserts.
- A consumer education program was developed to assess the ability of education intervention to change participants' knowledge, attitudes and dietary behaviors regarding functional foods.

Benefits:

- Animal tissue genes were screened for changes induced by increasing levels of dietary fiber. Changes indicate modification of cholesterol metabolism.
- Sugar was successfully replaced in two food products to decrease their caloric content and increase their dietary fiber content.
- Participants in a functional foods educational program had a positive view of functional foods and tried to eat more servings of some popular functional foods as a result of the educational intervention.

State Assessment of Accomplishments:

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

Key Theme: Human Health
FY '02 Focus Area: Scientific Basis for Optimal Health

Key Theme: Human Health

a. *Description* - Nutrition-related chronic diseases, such as coronary heart disease and cancer, are among the leading causes of death in the United States. Previous research at Purdue University has established that some sources of dietary fiber reduce cholesterol levels and excretion of bile acids in experimental animals. High blood cholesterol levels are a risk factor for heart disease, and high bile acid levels in the colon are a risk factor for colon cancer. The question now is, "What are the mechanisms by which these sources of dietary fiber cause these changes?" The Purdue University researchers are using microarray technology to screen hundreds of genes for changes in response to changes in diet. They fed rats 0% or 10% psyllium and then examined the expression of 1,691 genes in the rats' livers. The screening has identified 35 genes that were significantly changed by the addition of psyllium to the diet.

b. *Impact* - The 35 genes in rat livers that have been shown to undergo significant changes by the addition of psyllium to the diet include genes that modify cholesterol and acid bile metabolism and that affect transport of materials within cells, division of cells and many other functions that may be related to our risk for chronic disease. Further research is needed to be sure that these changes are meaningful, but the results will lead to a better understanding of the type and amount of dietary fiber to recommend to the public.

c. *Source of Federal Fund* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Nutricueticals

a. *Description* - The U.S. population consumes too little fiber and too much sugar and fat, according to U.S. dietary recommendations. Inulin, a natural carbohydrate found in the roots of some plants, has fewer calories than sugar and has some added health benefits, including reducing blood lipids and cholesterol. In some forms it is a fiber and it stimulates the growth of healthy bacteria in the gut, which improves digestion. Inulin can be used by diabetics and consuming it causes no known negative side effects. Purdue University researchers used a form of inulin, Raftilose P95, to replace some of the sugar in corn muffins and a low-fat frozen dessert. Muffins were made with inulin replacing sugar from 5% up to 100% inulin. The muffins were tested for sweetness, tenderness, outside appeal, and crumb appeal. Similar tests were conducted making a low-fat frozen dessert with substitution levels of inulin from 30% to 50%. The frozen dessert was tested for iciness, chewiness, sweetness, flavor intensity, color, texture, and viscosity.

b. *Impact* - Up to 40% of the sugar could be replaced with Raftilose P95 in the frozen dessert and still maintain the product's original sensory qualities. Results show that up to 15% of the sugar in a muffin mix could be replaced with Raftilose P95 without any detectable change in the product.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Human Nutrition
FY '02 Focus Area: Modifying Food Intake Behavior

a. *Description* - A program was designed to assess the ability of educational intervention to change participants' knowledge, attitudes and dietary behaviors regarding functional foods. The educational intervention used was designed by Purdue University Cooperative Extension and based on recommendations of the American Dietetic Association and the USDA Food Guide Pyramid. Included with the program is a pre- and post-test. Six weeks after the program, a follow-up test is mailed to participants. The program provided information on the types of foods that might be called functional foods, what they contained and how they might improve health and/or reduce the risk of some chronic diseases. People learned how to examine the validity of claims made about a food.

b. *Impact* - In 2001, the program was offered 12 times in seven counties. The program reached 254 people. The majority of the participants were female. Women are more often the teachers of food and health practices for the family, so reaching this population is particularly important. Of this group, 218 people took the pre- and post-tests and were mailed the follow-up test. The return rate on the follow-up test was 53%. Results indicated that the program significantly increased correct functional food knowledge as measured by comparing a pre- and post-test. Important gains in knowledge were a better understanding of the definition of a functional food and the fact that the Food and Drug Administration and the Federal Trade Commission were responsible for regulating claims made about functional foods. While some of the knowledge may have been reinforced by information from other sources during the six-week period after the program, it can be said that the program was effective in educating the participants about functional foods. Questions related to participants' attitudes regarding functional foods indicated that most of them viewed functional foods in a positive light. This did not change at the post-test or the follow-up test. The results of the attitudinal questions are similar to a study done by the International Food Information Council. There was no clear-cut change in behavior related to number of servings of functional foods after the six-week follow-up period. There was a positive correlation between those participants who said, on the post-test, that they intended to consume more servings of functional foods and the number of servings actually reported on the follow-up test. The participants reported consuming 17 or more servings of nine of the most frequently reported functional foods each week.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

GOAL 4: GREATER HARMONY BETWEEN AGRICULTURE AND THE ENVIRONMENT

Overview: Environmental issues and protection of our natural resources are of critical concern to Indiana's agricultural sector and rural population. Purdue University has a long history of research on these issues including work relating to land use decision making, animal waste management, biodiversity, the implications of genetically modified organisms, integrated pest management, and improving water quality.

TMDLs- Purdue University research is helping producers meet environmental quality standards such as those required under EPA's new animal waste handling rules and Total Maximum Daily Loads (TMDL) program. Recently, the state's revised 303(d) list has reported 428 impaired water bodies in Indiana that need to develop and implement TMDLs. Work at Purdue University is providing new computer modeling approaches for efficiently designing TMDL plans.

Nutrients- Purdue University researchers have demonstrated that dietary manipulation using phytase and fiber can reduce phosphorus and nitrogen contents in manure by up to 40%. This is a significant reduction since 14

million tons of solid and 1.6 billion gallons of liquid manure are produced by livestock at the state's 2,528 approved confined feeding operations.

Air Quality- More recently, Purdue University has taken the lead in assisting animal producers with air quality issues by developing computer models that improve building design and location selection. Research has shown that air borne ammonia content can be reduced by up to 60% using a modified animal ration.

Pesticides- Annually, agricultural producers apply some 21,699,000 pounds of herbicides and 800,000 pounds of insecticides to crops (corn, soybean and wheat) grown in the state. A Purdue University researcher has recently demonstrated that computer models can be used to dramatically lower the use of some chemicals, saving millions of dollars and lessening environmental exposure.

Hazardous wastes- Research at Purdue University has looked beyond traditional agricultural environmental issues to include projects on sites contaminated with heavy metals, cleaning solvents, sludges, acids, asbestos, petroleum and other industrial waste materials. This shift is important as many of the state's 7,000 leaking underground storage tanks, 245 brownfields and 33 hazardous waste sites are located in rural settings. Also application of agricultural and non-agricultural wastes to crop fields has been the focus of recent work. Research has confirmed the safety of applying biosolids to farm fields, while other work has shown that antibiotics applied to soil in sludge and manure are unlikely to leach to groundwater.

Research results under this goal have provided approaches, technologies, practices, and systems that enhance and sustain our resource base, while maintaining the productive capacity of the land and employment opportunities for our rural population.

Successes:

- Developed a swine diet manipulation procedure based on the addition of small amounts of specific fiber and synthetic amino acids that reduces aerial ammonia concentrations 49 to 60% and total nitrogen excretion by 30%.
- Demonstrated an animal manure management method based on the including high available phosphorus (HAP) corn and phytase in diets to reduce the phosphorus excreted from swine.
- Demonstrated in a five year study that current EPA 503 regulations for biosolid application limit the likelihood that extractable metals will become a hazard to human health.
- Demonstrated that leaching of the antibiotic Tylosin A from land applied swine manure is unlikely given the highly sorptive nature of both the parent and metabolites.
- Improved water quality sampling protocols by defining the frequency of drainflow sampling required to obtain accurate estimates of nitrate losses from farm fields.
- Developed a watershed delineation tool for use in Global Information Systems allowing nearly any user the capacity to obtain accurate information about a given location.
- Developed a novel and now widely applied method, for the delineation of wetland soils.
- In support of precision agricultural practices, developed a terrain assessment tool that utilizes satellite data for mapping slope, slope direction and surface drainage pathways to allow better site management.
- Developed a novel molecular genetic approach to evaluate soil monitoring data for gasoline contaminated sites. This technique will ultimately decrease the cost of site clean up by providing an accurate estimation of when cleanup goals are reached.

Benefits:

- Reduced the contribution of land-applied manure to polluted run-off by improving nutrient utilization efficiency in production animals.
- Reduced herbicide use and misuse by developing web-based systems that improve the process used to select herbicides for minor acreage crops.

State Assessment of Accomplishments:

The research initiatives under this goal are addressing Indiana priorities in soil, water and air quality conservation and management. Researchers have identified and evaluated technologies and tactics that can be used by producers to reduce negative environmental impacts. Producers have been provided with alternatives for manure management, reduction in pesticide use, and better decision making tools for improving the sustainability of their operations.

Key Theme: Agricultural Waste Management
FY '02 Focus Area: Water Quality

a. *Description* - Phosphorus derived from animal manure can lead to surface water eutrophication. Concerns have also been raised that applications of manure to soil may overload the soil with phosphorus leading to groundwater contamination. As a result, a much larger land-base is needed unless the amount of phosphorus in the manure can be lowered. Research has been conducted to develop methods to reduce litter (waste) phosphorus. Male Nicholas poults were fed one of nine diets consisting of industry diets; a National Research Council diet; or a diet containing 83% of the National Research Council diet requirement.

b. *Impact* - Purdue University researchers have shown a 42% reduction in turkey litter phosphorus levels when turkeys are fed a combination of fungal phytase and vitamin D metabolites. Turkey yield or performance was not affected. For the 14 million turkeys reared in Indiana per year, this would reduce the amount of phosphorus excreted by over 1000 tons per year.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Air Quality

a. *Description* - Environmental control strategies are being evaluated for reducing emissions of ammonia, hydrogen sulfide, carbon dioxide, dust, odor, volatile compounds, and bacterial pathogens from animal housing and waste storage and treatment systems. Base line emissions were measured for six months at a 250,000-hen laying house. Several types of ammonia analyzers were compared with chemiluminescence methods. Hydrogen sulfide and carbon dioxide were measured using pulsed-fluorescence, and infrared sensors, respectively. Tapered element oscillating microbalance was used for source measurements at livestock buildings for the first time. Fan operation was monitored along with building static pressure. Odor emission rates were measured using olfactometry. Along with five other universities, baseline emissions of odor, ammonia, hydrogen sulfide, carbon dioxide and particulate matter from mechanically ventilated livestock buildings are being measured for 15 months at two identical buildings at each university using the measurement methods described above. The study includes pig farrowing, gestation, and finishing barns and chicken layer and broiler buildings. Using data obtained from this project, a setback model has been developed to estimate nuisance impacts of livestock production systems based on

animal type and numbers, waste handling methods, building design and management, wind and climate characteristics, emission control techniques, waste storage type, land use, and topography.

b. *Impact* - Prior to this work most data on air emission from animal production facilities were estimates. Researchers at Purdue University and five other state universities have measured baseline emission rates of odor, hydrogen sulfide, ammonia, carbon dioxide, and particulates from a variety of swine and poultry buildings. For the first time, regulators have a sound scientific basis for developing guidance to reduce heath risks to farm workers and nuisance complaints in rural communities associated with animal agriculture.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Integrated Pest Management
FY '02 Focus: Improved Pest Control and FQPA Implementation

a. *Description* - A weather-based spray advisory program was developed from research conducted at Purdue University for the last five years. The MELCAST system (MELon disease foreCASTer) has been developed at the Southwest Purdue Agricultural Center in Vincennes, IN. By calling a toll free number, muskmelon and watermelon growers can find out when the weather is most conducive to diseases, and therefore when their crops need to be sprayed with fungicides. Not only does MELCAST help growers to apply fungicides when they are most needed, but in a normal year, growers will save two to three sprays per year. This represents a significant reduction of fungicide use and savings for the grower.

b. *Impact* - Growers report that they apply less chemical and spend less money on fungicides when using MELCAST. One grower reported he saved two-thirds his normal pesticide bill due to MELCAST. This grower has 150 acres of watermelons and spends approximately $15 per acre with eight to ten fungicide applications per year. In a year where fungicides are required frequently, this grower might spend $22,500 on fungicides alone. At least 52 growers used the MELCAST system this year, judging by telephone logs. If all these growers on average planted 150 acres of muskmelon or watermelon and cut their pesticide bills by two-thirds, over $2 million dollars would have been saved.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Indiana

Key Theme: Water Quality (1)

a. *Description* - The U.S.EPA has identified agriculture as the largest contributor of non-point source pollution. A Purdue University researcher is developing computer-based models and decision support tools to assess the extent of non-point source pollution and help identify potential solutions. One of these tools is a WWW-based Global Information System watershed delineation capability that was developed, tested, and interfaced to two hydrologic/water quality decision support tools (http://pasture.ecn.purdue.edu/~watergen/). The WWW-based watershed delineation system allows users with a broad range of experiences and backgrounds to quickly estimate the watershed boundary for any location of interest.

b. *Impact* - Unlike watershed maps that are commonly promoted, the WWW-based watershed delineation capability allows users to quickly and easily obtain estimates of local watershed boundaries for any location of interest. The watershed and its properties can be used within hydrologic and water quality

models interfaced with the system to identify water quality issues. The decision support system has greatly simplified the identification of water quality issues and potential solutions for current users, which include students and citizens interested in water quality issues as well as environmental professionals developing watershed management plans for communities.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Indiana

Key Theme: Water Quality (2)

a. *Description* - In order to improve water quality where high fecal coliform numbers have been detected, *Escherichia coli* has been commonly used as a target organism for investigations. A number of laboratories across the nation have been attempting to determine sources of fecal contamination in the environment using a variety of genetic fingerprinting methods. However, the genetic variability of the *E. coli* population of a single species of host animal has not been thoroughly examined for genetically based techniques. This uncertainty has contributed to the lack of standard methods for genetic fingerprinting *E. coli* in the environment. A Purdue University researcher is testing a variety of methods including rep-PCR (repetitive sequences using both REP and BOXA1R primers), AFLP (Amplified Fragment Length Polymorphism), PFGE (Pulsed-Field Gel Electrophoresis), and ribotyping on isolates from different sources to determine the most appropriate for regulatory use. *E. coli* known to belong to a single serotype O157:H7 were compared to other strains to determine the level of distinction between this pathogenic serotype and environmental strains. Comparisons of genomic DNA fingerprint patterns have indicated that all methods tested revealed a greater similarity between the *E. coli* O157:H7 strains than to any other strain types. The results indicate that AFLP, REP-PCR and BOX-PCR techniques can all be used for discriminating O157:H7 isolates and are preferred for large scale screening because of the speed and ease of the methods. Although ribotyping is also effective, its usefulness is limited by time if performed manually, and cost if automated. Although the most time consuming, the PFGE method is the best to discriminate between subtypes of O157:H7 associated with specific outbreaks so sources of food or water contamination can be tracked.

b. *Impact* - Regulatory agencies can now use with confidence genetic fingerprinting methods as indicators of the toxic *E. coli* O157:H7. These methods can detect the strain much more rapidly and accurately than traditional typing methods and provide more information that can help pinpoint the source of contamination, thus helping regulators better prevent exposure to toxic *E. coli*. While many methods for genetic fingerprinting are being touted, this is one of the first studies that provides regulators with information on the best means to determine sources of fecal contamination in the environment.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

Key Theme: Water Quality (3)

a. *Description* - Phosphorus is most often the nutrient that limits the productivity of freshwater ecosystems in the Midwestern United States. Agricultural fields can be non-point sources of phosphorus because manured fields and high testing soils may release large quantities of soluble and bioavailable phosphorus via surface runoff, erosion, and leaching. Researchers at Purdue University have developed a 'smart' document generator that queries data from Purdue University's Manure Management Planner software and other data sources to generate and insert tables at pre-defined locations in comprehensive nutrient management plan document templates created in Microsoft Word by the Ohio and Indiana Natural

Resource Conservation Service. The comprehensive nutrient management plan smart document generator is implemented as a custom tool for Manure Management Planner. Pre-written 'AutoText' entries provided as drop down menu choices can be inserted throughout the document to tailor the comprehensive nutrient management plan to the specific operation and site conditions.

b. *Impact* - Purdue University's Manure Management Planner is being used to create nutrient management plans for crop and livestock producers in 14 states, and support for seven more states will be added early in 2003. Manure Management Planner is the only software designed for this purpose that is supported nationally by Natural Resource Conservation Service. In Ohio, the comprehensive nutrient management plan document generator has reduced the time required to prepare a comprehensive nutrient management plan document from several days to a few hours. It is expected that the same workload reduction will occur in Indiana with additional time savings resulting from the implementation of the Indiana Offsite Risk Index as a custom tool for Manure Management Planner. When this is multiplied by the nearly 270,000 livestock and poultry producers estimated by Natural Resource Conservation Service to be in need of comprehensive nutrient management plans, this tool provides a tremendous savings of time and money that would otherwise be spent developing management plans.

c. *Source of Federal Funds* - Hatch

d. *Scope of Impact* - Multi-state

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 University researchers have established information resources that will aid in enhancing the quality of life for the people of Indiana. Quality of life has a different meaning depending on people's values, interests, economic status, and background. Purdue's role in developing information resources, services, and opportunities plays a key role in the development of the state's human capacity, generating employment opportunities, and contributing to economic growth. In fact, this is a top priority at Purdue University with direct leadership from the Office of the Provost. Engagement, following the recommendations of the Kellogg Report, with citizens across the state is helping Purdue University attract the necessary resources, despite the current weak economy, to create future economic opportunities in Indiana.

The 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 University. 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.

The New Ventures Team composed of Purdue University researchers and county extension staff is helping farmers develop value-added business proposals. An ethanol plant and a food-grade corn processing plant are currently in the finally planning phases and construction should begin in 2003. Also, agricultural economists have developed computer software that helps county government officials determine the fiscal impacts of local commercial, industrial, and residential development. This is very important information for local plan commissions and county commissioners.

Successes:

- Master Gardeners are reducing pesticide use.
- Research-based extension education programs are providing people with better information for retirement planning.
- Science-based, nondestructive technologies can help preserve older, historic buildings.
- A computer-based model can help local communities estimate the fiscal impact of commercial, industrial, and residential development.

Benefits:

- Oil and bio-insecticides are being used by homeowners to control insects in a safer manner.
- Personal finance education can result in financial security in later life.
- Nondestructive techniques can preserve in a more cost-effective manner older buildings, reduce restoration costs, and assure the public safety when historic structures are restored in our communities.
- A fiscal impact model for Indiana counties, municipalities, and school corporations allows local decision makers to analyze the tax revenue and budget expenditure impact of residential, commercial, and industrial development in a local community.

State Assessment of Accomplishments:

The many activities under this goal are addressing Indiana's needs in terms of improving the quality of life for the citizens in the state. Purdue University researchers have demonstrated approaches to be used by communities to make better decisions about policies that affect families. Also Purdue University scientists, working with county extension educators and various local stakeholders, are providing information on alternatives for debt reduction, tax restructuring, and planning and zoning.

5. A. Improved Quality of Life

Key Theme: Home Lawn and Gardening
FY '02 Focus Area: Improved Pest Control and Food Quality and Protection Act Implementation

a. *Description* - Over 30% of the Indiana Master Gardeners trained in non-chemical alternatives reduced pesticide use in the season following training. This coincided with a similar increase (27%) in individuals trying two or more new pest control tactics. The web is a viable resource for home gardeners. Gardeners were able to use Purdue University web-based resources, and quadrupled the use of related websites to 3500 hits per month.

b. *Impact* - Master Gardeners are reducing pesticide use. When they share their views with other gardeners in their communities, their friends and neighbors also reduce pesticide use.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Indiana

Key Theme: Home Safety

a. *Description* - The green industry and homeowners lack effective controls for armored scale insects. Control of these insects requires control tactics that can both reduce scale populations and conserve the beneficial insects responsible for long term control. By working with euonymus scale *Unaspis euounymi*

and its parasitoid *Encarsia citrine,* pesticides were identified that could reduce pest populations without adversely affecting natural enemies. Horticultural oil, and an insect growth regulator (pyriproxifen), were found to be the most effective and least likely to cause outbreaks of other pests. Both of these pesticides are on EPA's list of reduced risk pesticides because of their safety to the environment and low toxicity.

b. *Impact* - Homeowners can now use horticultural oil to control scale insects without adverse impact on non-target species. Landscapers can use a bio-based pesticide (pyriproxifen) that is effective in heavy infestations.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Multi-state

Key Theme: Retirement Planning

a. *Description* - During 2002, the distance education course, Planning For A Secure Retirement, was promoted throughout the United States through press releases, media interviews, conference presentations, and articles in the popular press. At the same time, Planning For A Secure Retirement, became part of the five-year Cooperative Extension National Initiative entitled "Financial Security in Later Life."

b. *Impact* - The purpose of the Initiative is to strengthen Cooperative Extension's capacity to deliver personal finance education leading to financial security in later life. The Initiative is delivered via the Internet (www.reeusda.gov/financialsecurity). The site is available to anyone with access to a computer and the Internet.

c. *Source of Federal Funds* - Hatch and Smith-Lever

d. *Scope of the Impact* - United States

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

Key Theme: Farm Safety

a. *Description* - Communities often debate what to do with older, historic buildings. Intensive evaluation by static load deflection tests and vibration tests of the floors was conducted over a six month period of an historic structure before it was razed. It was possible to determine the damped natural frequency for the long span (21 ft.) floor sections. However, for the 12 ft. span floor sections the vibration response was problematic. The comparatively short deep joists (2 by 15-inch by 12 ft.) in these sections might violate the assumption of a slender prismatic member that is necessary for the application of the theory used to calculate natural frequency. Also in addition to transverse vibration of the short span sections, torsional vibration may be occurring. Thus, the basic assumption of pure transverse vibration would not apply. For the long span floor sections, the test results continue to support the hypothesis that the in-place floor can be modeled as a transversely vibrated, simply supported prismatic member. This model allows prediction of floor stiffness based on measured damped natural frequency. As the older building was being demolished, three complete and intact floor sections were hoisted by crane from the building. Two of the sections were long span and one was short span. The sections, two consisting of eight joists and the third had nine joists, were cut from the continuous floor that had been extensively tested. These floor sections were removed to an outdoor site for further testing to assess the validity of the nondestructive vibration testing techniques.

b. *Impact* - This nondestructive vibration testing techniques make it possible to assess in-place floors. This makes it possible to determine the safety of retaining, replacing, or destroying floor systems in older, historic buildings in rural communities or in state and national parks.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - United States

Key Theme: Impact of Change on Rural Communities

a. *Description* - A fiscal model was developed for Indiana counties, municipalities and school corporations. The fiscal impact model compared estimates of the added revenues and added costs generated by a new development. This model takes into account of the type of development (residential, commercial, industrial), the density of development, and the existing capacity of the local governments. The fiscal model is integrated with models of water quality and wildlife habitat to provide a more comprehensive decision-making tool for local officials. To construct a model usable by local decision makers, data on the budgets, appropriations, revenues, tax rates and population characteristics of 92 counties, 294 school corporations and 560 cities and towns were collected.

b. *Impact* - A fiscal impact model for Indiana counties, municipalities, and school corporations was developed which allows local decision makers to analyze the tax revenue and budget expenditure impacts of residential, commercial, and industrial development in a local community.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Indiana

Key Theme: Promoting Business Programs

a. *Description* - The potential for agribusinesses using word-of-mouth marketing was evaluated by examining one particular form of word-of-mouth marketing, facilitated teleconferences. It was found that this word-of-mouth marketing approach was extremely effective as measured by participants' recollection of the program, participants' willingness to participate again, participants' willingness to recommend the program to others, and the level of information the participants acquired.

b. *Impact* - Companies will find facilitated word-of-mouth marketing most effective if they target customers who are opinion leaders, as well as larger customers who are maintaining or increasing the size of their operation.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Multi-states

Key Theme: Promoting Business Programs

a. *Description* - A survey of Indiana family business owners that focused on family and business functioning was conducted. Most family business employed 20 to 99 people with an average of 57. Spillover between the family and the business (home to work and work to home) was expected to have a negative influence on the success of the family and business and on satisfaction with both. Better family communication was found to be associated with greater satisfaction and less stress. Better business practices were associated with better business outcomes, but there was an interaction effect with co-

mingling of home and business finances that reduced business outcomes. Minimizing spillover (and maximizing communication) increases the likelihood of success for both the family and the family business. Family communication seems to contribute to some indices of business health, and business practices seem to contribute to some indices of family health offering some empirical evidence that what is good for the business is also good for the family. The research results suggest that the business should be run like a business (and not like a family), that co-mingling of family and business finances can hinder success, and high communication is important to the success of the family and its business.

b. *Impact* - Family business owners can easily make inadvisable business decisions. They may hire family members who are underqualified and overcompensated, or co-mingle family and business funds. Purdue University provides family business education to undergraduate and graduate students, and to family business owners. Family business education was offered to family business owners through a website (http://www.cfs.purdue.edu/csr/ifb), through on-campus educational programs, and through the Farm Progress Show.

c. *Source of Federal Funds* - Hatch

d. *Scope of the Impact* - Multi-state

B. STAKEHOLDER INPUT PROCESS

Engaging stakeholders is a priority for Purdue University. Indeed, the Purdue University Strategic Plan approved by the Board of Trustees in November 2001 makes it very clear that engagement with local, state, national, and world audiences is one of the primary missions of everyone at Purdue University. In the 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 across the state and Nation. About one-fourth the faculty in the 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, field days, conferences, etc. Staff participate in a wide variety of state and local events including conferences, commodity marketing associations, and agricultural interest group meetings. Purdue University is reaching new key stakeholders as evidenced by the hundreds of people attending annual horticultural and turf management conferences. In fact, these "green" industry events now attract more participants than the more traditional agronomy or swine field days. Several 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. Examples include industry advisory boards for the Department of Food Science and the Crop Diagnostic Center. The Center for Food and Agricultural Business trains more than 1,000 agribusiness leaders annually with over 100 days of programmed events. Every session is evaluated by the participants.

Another way our faculty and staff remain engaged with stakeholders is through a highly diverse group of organizations that involve producers and citizens with interests in agriculture and natural resources. Purdue faculty and administrators act as *ex-officio* members or liaisons with 14 of these organizations. These groups are diverse, meet regularly, and are often focused on a particular interest, providing us with an excellent way to interact with a wide cross-section of agriculture interests. The Director and Associate Director of Agricultural Research Programs are both members of the Agricultural Alumni Seed Improvement Association Board of Directors. This facilitates the release of public varieties of wheat and soybeans as well as germplasm. The Associate Director serves as the liaison with the Indiana Soybean Board and coordinates the transfer of soybean checkoff money to faculty under a competitive research grant arrangement. The Associate Director is a member of the Purdue University Institutional Review Board for human subjects' research, and he also serves on the

human subjects' subcommittee for Extension program evaluation statewide. This not only assures protection of human subjects, but links stakeholders and researchers in program evaluation efforts.

The Department of Foods and Nutrition in the School of Consumer and Family Sciences has frequent meetings with a Corporate Affiliates Advisory Board. The Department of Food Science has an Advisory Board composed of executives in the food processing sector who periodically meet on campus.

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

Purdue Council for Agricultural Research, Extension, and Teaching

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

PCARET holds regional meetings throughout the state in both the spring and fall. At every meeting, representatives from the School of Agriculture attend to update PCARET members on state and national legislative initiatives and programs. An annual meeting for all PCARET members was hosted on the Purdue University campus in November 2002. Sessions were offered on a variety of topics including a discussion of a statewide life science initiative involving Purdue University, Indiana University, DowAgroSciences, Eli Lilly, and other plus a presentation on Discovery Park and the Purdue Research Park. Discovery Park is involved in biotechnology, nanotechnology, and entrepreneurship research. The Purdue Research Park is the home of incubator activities that help new businesses commercialize scientific discoveries. Elected members of PCARET annually travel to Washington DC. They also participate in the annual July North Central Mini-Land Grant Meetings with representatives from ACOP, ESCOP, ICOP, and ECOP. Indiana has one of the most active and effective CARET organizations in the United States.

Dean's Advisory Council

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

School of Agriculture Roadmapping

Purdue University has developed, and the Board of Trustees has approved, a Strategic Plan for the entire University. The School of Agriculture completed in 2002 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 administrators and selected faculty at a daylong retreat that kicked off our roadmapping effort. There were subsequent opportunities for feedback from stakeholders as the plan evolved. Stakeholders were asked to respond to three questions: 1) What is the current state of Purdue's agricultural programs?, 2) What should the future look like?, and 3) What steps would be needed to get there? Issues discussed included diversity, research needs, agricultural issues of the future, and economic development. They also helped identify 14

different issue areas to be developed into action plans. The School of Agriculture's Strategic Plan has been approved by the Office of the Provost. Each Department in the School of Agriculture is now completing a department-level strategic plan to submit to the Dean of Agriculture. Departments have sought input from their various stakeholder as they developed their strategic plans.

The Purdue University Strategic Plans calls for hiring 300 additional faculty over the next five years. The Schools of Agriculture, Veterinary Medicine, and Consumer and Family Sciences will all benefit from these new hires. Priority is being given to three criteria: 1) replacement of Teaching Assistants with faculty, 2) cluster hires to focus research and extension expertise on key problem areas where there is a priority need expressed by stakeholders plus funding opportunities, and 3) diversity sensitivity. Last year nearly one-half of the new faculty hires represented women and/or minority hires. This will help Purdue University better reflect the profile of stakeholders that we serve statewide.

Indiana Crop Improvement Association

Purdue University has a very close working relationship with the Indiana Crop Improvement Association. Faculty are speakers at their annual meeting and share in program planning. There has been a significant collaborative research effort over the past few years that has resulted in the development of CystX. CystX technology can genetically transform soybeans to be resistant to the cyst nematode, a serious soil pest problem in much of Indiana that reduces soybean yields.

Indiana Plant Food and Agricultural Chemical Association

The Indiana Plant Food and Agricultural Chemical Association is composed of individuals from the agricultural service community in Indiana. A typical member sells agricultural chemicals or fertilizers or manages a retail operation. A Purdue University faculty member serves on the board of directors of the Indiana Plant Food and Agricultural Chemical Association in an *ex-facto* status. Meetings of the Indiana Plant Food and Agricultural Chemical Association Board of Directors are held monthly where ideas and issues are discussed. The group also has an active email list and web site where information is exchanged.

Office of the Commissioner of Agriculture

In Indiana, most state regulatory functions are located on the West Lafayette campus, e.g. Animal Disease Diagnostic Laboratory and the State Chemists Office. The Lt. Governor serves as the Commissioner of Agriculture. The Dean of Agriculture, Director of Agricultural Research Programs, and other administrators have frequent contact with the Lt. Governor's Office and other state officials. Also Mr. Jim Mosley, Deputy U.S. Secretary of Agriculture, is an Indiana farmer and is in frequent contact with Purdue University officials on a variety of topics such as bioterrorism.

Commodity and Farm Organizations

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

Special Stakeholder Events

In September 2002, the Office of Agricultural Research Programs co-sponsored with the Indiana Farm Bureau in Indianapolis an Agricultural Summit entitled “Biotechnology, Gene Flow, and Intellectual Property Rights.” Over 100 people attended including Indiana farmers, seedsmen, state legislators, Purdue University faculty, state agribusiness leaders, the news media, and commodity and general farm organization staff. Workshops such as this enhance the dialogue among university administrators and faculty with various state stakeholders on critical controversial technologies and policies.

C. PROGRAM REVIEW PROCESS

The Office of Agricultural Research Programs manages the research portfolios on the principle of one research project per investigator in most cases. However, multi-investigator Hatch projects are considered on a case by case basis where multidisciplinary teams are appropriate. Every Hatch Review Panel includes faculty from at least two different disciplines. Research collaboration among faculty across departments, schools, and universities in other states is strongly encouraged. Project proposals are reviewed as described in the Plan of Work.

D. EVALUATION OF SUCCESS OF MULTI AND JOINT ACTIVITIES

Faculty associated with the Office of Agricultural Research Programs at Purdue University are involved in over 100 multi-state projects managed through the four Regional Experiment Station Executive Director offices. These projects have a broad disciplinary base. Also all these multi-state research projects are relevant to one or more of the five USDA-CSREES goals. The Office of Agricultural Research Programs reimburses them for expenses associated with participation in approved multi-state research meetings.

Eleven states, including Indiana, are actively involved in a multi-state project addressing adolescent nutrition. Researchers are developing and validating a survey instrument that focuses on key identifiable constructs that may influence the consumption of calcium rich foods among Asian, Hispanic, and White girls and boys ages 11-12 years and 16-17 years. The major themes identified in the instrument are taste preferences, health beliefs (calcium's role in health, weight concerns, and tolerance), family (family's influence, consumption, and expectations), independence, eating occasions, eating location (school and restaurant), and food availability. Over 1800 children from 10 states (AZ, CA, CO, HI, ID, IN, NV, NM, WA, WY) have completed the initial survey. In Indiana, 446 questionnaires were completed. The results from this project will be used to design effective, tailored nutrition intervention among adolescents with the goal of reducing their risk of osteoporosis later in life.

Despite the passage and enforcement of U.S. EPA 503 regulations, concern still exists about potential long-term contamination and health effects of metals in biosolids applied to soil. Five municipalities were identified from across the United States. They represent a broad sampling of geographic locations and soil types. The research team visited each city, sampled the biosolids, soil amended with biosolids that year, soil amended with biosolids for five or more years, and clean soil. All facilities were following the guidelines of the EPA 503 regulations. In addition, soil was sampled from a large city that had received non-compliant (high metal) biosolids for 20 years, and a soil that had received 20 tons per acre of high metal sludge 25 years ago. Bioavailability and chemical lability of metals were evaluated using earthworm tests (mortality, weight gain, and reproduction), lettuce germination, microbial respiration, nematode toxicity, and extractability with a series of chemical solutions. In all cases, the application of sludge did not impact significantly any of the bioindicators relative to the clean, control soils. Extractability of the metals likewise was unaffected by a single year's application of biosolids. However, five years or more of biosolid application resulted in approximately 5 to 10% more extractable metals than in the absence of application. The high-metal sludges had slightly elevated metal concentrations. The conclusion from this study is that metal toxicity is not an issue for field application of these biosolids because nitrogen and phosphorus are limiting the quantity of material that may be applied. Only in cases in which nitrogen and

phosphorus are low will metals limit the rate of application, and higher levels of potentially toxic metals may be possible. Even under those circumstances, it seems unlikely that the metals will reach toxic levels. Thus, despite the ongoing concern about whether or not the EPA 503 regulations are conservative enough, if the guidelines are followed over the short-term (one to five years) the environment will be protected.

Regional cooperation to develop rootstocks is critical to the economic viability of the apple industry. Final data were collected from a planting initiated in 1992 looking at five dwarf and six semi-dwarf apple rootstocks. A New York rootstock, CG 202 looks promising as an alternative to the standard M.9, but fruit size has been slightly smaller. None of the semi-dwarf rootstocks in this planting appear to be significantly better than M.7. In data from other plantings, B.9 continues to perform similarly to many of the M.9 subclones, and although survival has been good in Indiana, in other sites the survival of B.9 has been considerably better than M.9 trees. Data collection from two 1999 plantings has terminated due to high tree mortality caused by cold conditions at planting and poor tree condition at that time. A new planting comparing the performance and survival of 11 apple rootstocks was established in 2002. Rootstocks affect the performance of fruit trees more than any other factor. Based on the results from data from this project, apple breeders are recommending B.9 to Indiana growers as a high performance dwarfing apple rootstock. This is of particular use in U-pick plantings where the use of ladders, and associated liability risk, is eliminated.

The purpose of this multi-state project is to track and assess the functioning and well-being of rural low-income families in each state over a four year period. Both structured and unstructured face-to-face interview data are being collected from participating families. Wave one data collection (the standardized questionnaire plus additional questions originated by Purdue University on credit use); transcribing and verification is complete. Wave two data collection and transcribing is complete. Preparations are being made for Wave three data collection. It is anticipated that Wave three data collection will be completed by March 2003. Preliminary data analysis on credit use indicates that lay-away was the source of credit used most frequently by these Indiana families. Further, those families who used pawn shop, rent-to-own and pay-day loans most frequently reported problems. This multi-year, multi-state project will provide information on three levels. On the family level, measures of quality of life of low-income rural residents include income sufficiency, food security, and health. On the community level, indicators of economic and social development are included. Finally, on the policy level, measures of risks and opportunities for low-income rural residents and counties in terms of state and national welfare policies are included.

F. INTEGRATED RESEARCH AND EXTENSION ACTIVITIES

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

Institute Purdue University

State Indiana

Check One:

_____ **Multistate Extension Activities**
X **Integrated Activities (Hatch Act Funds)**
_____ **Integrated Activities (Smith-Lever Act Funds)**

Title of Planned Program/Activity	**Actual Expenditures FY2000**	**FY2001**	**FY2002**	**FY2003**
Sampling Frequency Requirements for Tile Drain Outflow Measurements			38,597.79	
Five State Beef Initiative Producer Training and Certification			5,937.66	
A Good Cow is a Good Cow			6,929.31	
Diet Manipulation to Reduce Swine Manure Nutrients and Odors			25,526.44	
CystX(R) is On Track			54,125.48	
Indiana/Illinois Areawide Rootworm Pest Management Program			17,738.73	
Enhancing Alfalfa Performance			78,227.59	
Environmentally Friendly Fumigant Can Improve Food Safety			7,001.61	
Conservation Tillage			25,533.02	
Measuring Competitiveness of U.S. Pork Market			21,343.68	
Tax Professionals Learn About Tax Changes From Purdue Income Tax School Program			16,765.01	
Improving Food Safety in Apple Production			9,544.94	
Total			308,271.26	

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Sampling Frequency Requirements for Tile Drain Outflow Measurements

Researchers, government agencies, watershed groups, and farmers often want to sample tile drains for nitrate to determine the contributions of agricultural management practices to nitrate loadings in ditches or streams. The frequency of sampling needed to obtain an accurate estimate of annual nitrate loadings is not known, and most groups want to analyze as few samples as possible. Three years of data from a long-term tile drainage research site was collected at the Southeast Purdue Research Center to test the relative accuracy of weekly, monthly, or quarterly nitrate analyses for estimating annual nitrate loadings. The calculated estimates were compared to the

"true" loadings calculated from all available chemical samples. Probabilities of estimating the annual nitrate-N losses within 15% of the "true" loss were 92% for weekly sampling, 68% for monthly sampling, and 51% for quarterly sampling.

The frequency of drain-flow sampling required to obtain estimates of nitrate-N losses from tile drains depends on the accuracy requirement of the intended use of the data. Water sampling and analysis is a costly undertaking. Data from long-term field experiments can help determine cost-effective sampling strategies for future water quality sampling sites, and will provide producers with the information they need to stay within the limits of nutrient regulations. These results have been shared with growers, fertilizer suppliers, and other interested stakeholders during field days at the research farm.

Five State Beef Initiative Producer Training and Certification

Consumers are becoming more concerned about where their food comes from, and how it is produced. At the same time, beef producers are looking for ways to increase profitability by adding value to the products they produce. The Five State Beef Initiative has developed training materials for beef producers in five areas: 1) beef quality assurance and health, 2) animal handling and well-being, 3) genetics, 4) data management, and 5) environmental stewardship. Eleven face-to-face meetings across Indiana, and one state-wide televised program were conducted to train and certify producers in these five areas. Each producer completed a pre-test prior to training to assess base knowledge. A post-test was administered following training for certification.

The Five State Beef Initiative has trained and certified 107 producers in Indiana since January 1, 2002. An additional 358 producers had been similarly trained and certified under the old IQ+BEEF program and were grandfathered into the Five State Beef Initiative program. The IQ+ producers were mailed updated materials to complete the training, certification, and grandfathering process. These producers have been trained and certified in the areas of beef quality assurance and health, animal handling and well-being, genetics, data management, and environmental stewardship. These certified producers are eligible to participate in the Five State Beef Initiative (a vertically coordinated production, marketing, and information sharing system) designed to increase producer profitability by meeting consumer demands and expectations.

A Good Cow is a Good Cow

Grazing as a form of low input dairy production is increasing in popularity. Herds where cows consume mostly grass forage produce, on average, less milk than those in confinement. However, it has also been documented that the lower costs of production associated with grazing are more than enough to offset this decreased production. A major concern for grazers is the choice of genetics for optimal performance in pasture based systems. A primary concern is whether a genotype by environment interaction exists between the two distinct environments, confinement and grazing. In other words, does one expect those sires, whose daughters are producing in both environments, to rank the same genetically in both environments? Production records were obtained from grazing herds in the Eastern United States. Grazing herds were defined as those that utilized grazing for at least 6 months and were enrolled in Dairy Herd Improvement Association. Control herds were confinement Dairy Herd Improvement Association herds of comparable size in similar regions. The performance of daughters of bulls in grazing herds and control herds was compared by examining the relationship between milk, fat, and protein yield. Predictions were based upon USDA genetic evaluations of artificial insemination industry bulls. Estimates of heritability for the traits ranged from 20% to 25%, and differences between grazing and control environments were small. Estimates of the genetic correlations for the traits in both environments were significantly different for unity for milk (0.89), fat (0.88), and protein (0.91). Grazing and control records were also examined for evidence of genotype-by-environment interaction among somatic cell counts and reproductive traits. Little evidence for genotype by environment interaction was found.

Grazers are convinced that bull's daughters fed mainly grass perform differently than those fed more concentrates indoors. Our work shows that a bull's daughters tend to rank the same compared to other bulls regardless of the environment. Therefore, grazers can select bulls for the specific combination of traits, no matter where most of their daughters were raised. There is some genotype by environment interaction for production traits between confinement and grazing herds in the United States. However, a young sire sampling scheme solely to identify sires that excel under grazing, does not appear to be economically feasible given that a high level of genetic gain will be achieved by selecting sires based on current evaluations. Grazers can confidently use bulls tested primarily in conventional dairy environments. Indeed use of artificial insemination sires instead of natural service sires from other grazing herds will result in an increased value of at least $210 per heifer over the course of her life. For a 100 cow grazing herd, this equates to $10,500 per yearly calf crop.

Diet Manipulation to Reduce Swine Manure Nutrients and Odors

A major threat to the growth and sustainability of the pork industry in Indiana and throughout the nation is the public concern about potential water quality problems and manure odors caused by confined feeding of swine. In addition, the health and well being of swine and humans working in swine facilities are at stake. Stricter laws in many surrounding states and the recent adoption of stricter water quality rules for confined feeding operations in Indiana has put considerable pressure on the pork industry. In addition, there is a concerted effort to develop air quality standards and rules in Indiana that will affect livestock and poultry operations. The objectives of these research and extension activities were to determine the effects of diet manipulation on manure excretion nutrients, odors, and to develop management techniques to significantly reduce nutrient excretions and odors from swine operations.

In group feeding research studies with growing-finishing pigs, reducing the crude protein of diets and supplementing with synthetic amino acids, the addition of 5% soybean hulls and elimination of mineral sulfate ingredients in the diet reduced the excretion of total nitrogen in fresh manure by 27 to 30%. However, aerial ammonia concentrations in the housing room and exhaust air were reduced by 49 to 60% by feeding the low crude protein-synthetic amino acids diets. In addition, hydrogen sulfide and the odor detection threshold were reduced by 43% and 39%, respectively with the low crude protein diets. By using high available phosphorus corn and phytase in the diet, phosphorus excretion was reduced 52%. With sufficient amino acid levels in the diets, pig performance and carcass characteristics were similar to those from pigs fed a typical commercial diet. Low carbon/phosphorus diets with synthetic amino acid additions and a low level of fiber were effective at reducing aerial ammonia concentrations, hydrogen sulfide, and odor detection threshold and manure nitrate excretion. Replacing normal corn in the diet with high available phosphorus corn and adding phytase reduced phosphorus excretion. Diet manipulation is a practical and economical management practice that can sustain pork productivity and profitability while sustaining or improving water and air quality. Faculty in the departments of agricultural engineering and animal science have worked closely with the Indiana Pork Producers Association and technical staff with the Indiana Department of Environmental Management to consider these diet management practices as environmental regulatory guidelines are being written.

CystX(R) is On Track

The U.S. losses to soybean cyst nematode, the most destructive pest of soybeans, are estimated at $1.4 billion annually. The main tool for managing soybean cyst nematode is plant resistance, but most resistant varieties allow some soybean cyst nematode development, depending on the virulence of the particular field population. This may reduce yield, but also may result in soil buildup of soybean cyst nematode. A completely resistant variety (Hartwig) prevents soybean cyst nematode soil buildup, but exhibits yield drag and is difficult to incorporate into high yielding varieties.

Researchers at Purdue University and the Indiana Crop Improvement Association discovered and developed soybean germ plasm with broad-based and complete resistance to soybean cyst nematode, no yield drag, and that can be easily crossed with high yielding soybean lines. The new technology has been licensed to breeders and seed companies by Access Plant Technology under their trademarked logo CystX®.

CystX technology is working well, and each year new lines are reaching the marketplace. During the 2002 growing season, new CystX® lines were tested in replicated yield trials by Purdue Extension Specialists and a number of seed companies are developing new CystX® lines. Many of these were resistant to soybean cyst nematode and competitive in yields with top soybean varieties. Two of the new lines will be ready for commercial sale in 2003. A backcross of the original germ plasm developed by the Purdue University/Indiana Crop Improvement Association researchers was marketed for planting in 2001 as a branded variety. Soybean farmer Jim Murray of Pulaski County, IN, said that his CystX® plants yielded more in 2001 than the best soybean cyst nematode resistant Roundup Ready varieties, and in some areas gave him his best yields since 1986.

Indiana/Illinois Areawide Rootworm Pest Management Program

It is expected that the U.S. Environmental Protection Agency will ultimately remove or limit the use of many agricultural pesticides. It is essential that suitable replacement products and/or technologies be developed and evaluated before the loss of the more traditional products is felt in the farming community. One example where new control options will be essential is managing the economically important Western corn rootworm. A variant form of this pest, sometimes referred to as “rotation adapted” rootworm, was first noted in northern Indiana about 10 years ago. This variant has adapted to the corn/soybean rotational system. This development virtually eliminates crop rotation as an effective tool for managing Western corn rootworm. In a 2001 farmer survey, one-third to one-half the respondents in the most heavily infested northern Indiana counties indicated that crop rotation was less effective now than in the early 1990s as a means for controlling corn rootworms. Prior to the discovery of this variant, farmers in the 1980s had decreased soil insecticide used for Western corn rootworm control by about 60% through crop rotation. In 2000, it was estimated that 2.1 million acres of Indiana’s 5.7 million total acres of corn (37%) were treated with insecticides, primarily for rootworms. Of these acres, about 90% were in rotation. This was up from the 1.5 million acres of 6.1 million acres of corn (24%) treated in 1994. The 2000 percentage, however, does not show the full impact of this variant since the above totals represent the statewide average. The variant is presently primarily concentrated in northwestern Indiana. In the most heavily infested 10-county region in northwestern Indiana, farmers report treating 77% of the corn acreage with soil insecticides, while in southern Indiana, where there are few corn rootworm problems in most years, less than one-third of the corn acres are treated. This increase in soil insecticide use is both environmentally and economically significant. By reducing beetle numbers throughout the areawide site in 2001, with the semiochemical insecticide bait Invite, lower numbers of eggs should have been laid in soil where corn was planted in 2002. To determine the effectiveness of Invite in 2001, corn roots were evaluated for rootworm larval damage in 2002. The average of means for rootworm larval damage (based on the Hills & Peters 1-6 root-rating scale) within the managed area was 1.84 in treated strips and 2.27 in untreated strips (no soil insecticides). Outside of the managed area, the average root rating was 2.16 in treated strips and 3.51 in untreated strips. A significant difference between check strips within the managed area versus the control area was detected.

When the Areawide Pest Management program was initiated in 1997, approximately 5,300 acres of corn within the managed site were treated with a soil insecticide, or 90% of the corn associated with the program. Currently, 76% of the corn is treated with a soil insecticide. Therefore, as a result of this program, growers have cut back on soil insecticide use by 14% even before all the research data have been analyzed. In 2002, with the reduction of soil insecticide use, this translates into a savings for the growers in the 16-square mile site of about $15,000. The use of alternative pest control tools, as validated in the Indiana/Illinois areawide corn rootworm management program, will save producers millions of dollars if fully implemented statewide over the next 10 years and will satisfy Food Quality Protection Act requirements. Results of this work have been shared with USDA-ARS and

Midwestern Land Grant University scientists, at grower and professional meetings, and via websites and extension publications.

Enhancing Alfalfa Performance

Alfalfa is often grown on marginal lands that have low fertility because better lands are reserved for corn and soybean production. Low yield and poor plant persistence often results from the poor fertility. The relationship between potassium and phosphorus fertility and alfalfa productivity was re-examined. Plots established in 1997 have received one of 20 fertility combinations, and yield, components of yield, and root physiology have been compared. Soil test phosphorus and potassium levels are being examined by soil depth increment in order to understand the impact of phosphorus and potassium stratification on alfalfa performance. Poorest alfalfa performance is being obtained on plots receiving high phosphorus rates with no potassium fertilizer (worse than the 0 potassium-0 phosphorus plots). Good forage yield and acceptable persistence are obtained when at least 200 pounds of potassium and 50 pounds of phosphorus are provided per acre.

Balanced phosphorus and potassium nutrition are essential for successful alfalfa production. Purdue Extension now recommends that soil testing is best done in autumn, since spring derived values overestimate potassium availability. Research also has established that providing at least 200 pounds of potassium per acre and 50 pounds of phosphorus per acre are necessary for high forage yield, but this potassium rate is inadequate for building soil test potassium levels. These results have been shared with growers and county Extension educators during June Hay Days at the various Purdue Agricultural Centers.

Environmentally Friendly Fumigant Can Improve Food Safety

Insects and molds invading food can create health risks for both people and animals when they feed and defecate on it. In addition to the direct effects, this damage can promote mold formation, primarily, *Aspergillus* and *Fusarium*. These molds release dangerous toxins linked to sometimes-fatal diseases in most livestock species. *Fusarium* has been linked to cancer-causing mycotoxins in humans. Few methods currently are available to prevent insect and mold damage to stored grains. Development of an environmentally safe fumigant for agricultural products became a priority with the 1987 Montreal Protocol, an international agreement to ban substances deemed dangerous to the Earth's ozone layer. The treaty banned methyl bromide, commonly used against crop pests in the soil and in storage facilities. Purdue University researchers and extension specialists studied the use of ozone as a fumigant on rice, soybeans, wheat, corn and popcorn stored in grain bins. Ozone, a powerful oxidizer, reduced damage by insects such as beetles and moths and the fungi *Aspergillus* and *Fusarium*. The researchers studied how much contamination was reduced through ozone fumigation and how quality was affected. Ozone fumigation of stored grain killed insects and prevented fungus development without altering production quality of the treated raw grains.

More grain can be kept safe from insects and molds by using environmentally safe ozone as a fumigant. This fumigation method also protects the production quality of the raw grains. This method currently has only been tested on stored raw grain. However, Purdue University researchers believe that it eventually can be used for processed food. Ozone as a fumigant has the potential to reduce the number of food-borne illnesses, which the Center for Disease Control estimate are approximately 76 million cases annually in the United States. Using ozone as a fumigant increases food safety by lowering health risk to people and animals. The authors of this study have conducted several workshops and training session in the Midwest to encourage farmers and other grain handlers to adopt the use of ozone for stored grain management.

Conservation Tillage

Conservation tillage adoption for corn has lagged behind that of soybean in Indiana. Almost 60% of Indiana's soybean crop is no-till planted while no-till corn represented less than 20% of the total corn acreage from 1995 to 1998. Full width tillage systems for corn after soybean leave the soil surface with less than 30 % residue cover (the minimum to be considered as conservation tillage), and thus leaves soil very vulnerable to erosion. No-till adoption for corn was promoted through extension activities, and fall strip tillage research was conducted on university farms. The latter practice preserves two-thirds of the surface residue of no-till, and enables earlier corn planting in spring. In early spring, soils were both warmer and drier on the "berms" left by strip tillage implements. Corn yields after strip tillage have been at least as good as those after full-width tillage systems that eliminate most residue cover after soybean. Strip tillage permits most of the erosion benefits of no-till with less risk of delayed planting or poor corn plant establishment (particularly on fine-textured or poorly drained soils).

Fall strip tillage was estimated to be adopted on 150,000 corn acres in 2002. It represents between 5 and 15 % of the so-called "no-till acres" determined annually by a transect survey in each county in Indiana.

Measuring Competitiveness of U.S. Pork Market

The pork slaughter industry has become extremely concentrated leading to worries about imperfect competition on the part of hog packers. Dr. Jason Henderson at the Kansas City Federal Reserve Bank, along with a Purdue University economist, estimated the aggregate degree of market power for the hog slaughter sector in the United States in both the live hog market and the wholesale pork market. They found that substantial market power exists in the wholesale pork market, but did not find evidence of direct market power in the live hog market. Market power in the wholesale pork market does, however, tend to depress the demand for live hogs and lower prices.

On average, they reported that wholesale pork prices are inflated by as much as 49 percent due to imperfect competition. This measure of imperfection has implications for farmers who are interested in downstream investment because it means that existing packers may have a lot of room to undercut producers who make such investments. Consequently, it may be difficult for such producer action to succeed.

Tax Professionals Learn About Tax Changes From Purdue Income Tax School Program

Major income tax legislation affecting individuals was enacted in 2001. Some provisions were effective for 2001, others in 2002 and still others in later years. This recent legislation adds greater complexity to the income and self-employment tax laws and regulations making it more difficult for individuals and small businesses to comply with the law. Purdue Extension, in cooperation with the Internal Revenue Service and the Indiana Department of Revenue, developed educational materials and presented programs to update tax professionals on the new law, regulations and procedures. In addition to information enabling taxpayers to comply with the law, educational materials designed to help individuals understand and evaluate their management alternatives were developed. Two-day programs were held in 11 locations in Indiana and three, four-hour programs focused on agricultural tax issues. A two-hour program for farmers was presented on the Indiana Higher Education Television System network.

Purdue Extension, together with the Internal Revenue Service and Indiana Department of Revenue taught nearly 1,250 tax professionals about tax law changes at 11 two-day programs. These tax professionals filed over 39,000 farm returns, about two-thirds of all the farm returns filed in Indiana, and over 305,000 non-farm federal returns. Over 70 percent of the individuals responding rated the program as "excellent" or "very good". The three, four-hour programs were attended by 130 tax professionals filing about 100 farm returns each. Clearly, the research-based tax education materials have a profound impact on the filing of farm and non-farm tax returns in Indiana.

Improving Food Safety in Apple Production

The Food Quality Protection Act, passed in 1995, mandated that the EPA review potential harmful effects of pesticides used on food crops. Apples, because of their high consumption by children, were targeted as the number one potential source of harmful effects of pesticides on children's health. Indiana apple growers have relied on organophosphate insecticides to manage many serious pests that attack their crop. The EPA targeted organophosphate insecticides as the group most likely to cause problems for children's health. As a result of their review, the EPA eliminated several organophosphate insecticides and limited the use of others that apple growers relied upon. There are no readily apparent alternative methods available for insect control on apples. In 1995, Purdue University scientists conducted a pesticide use survey of Indiana apple growers to establish a baseline against which to compare use patterns. Numerous studies have been conducted since then to evaluate possible replacement strategies for organophosphate insecticides. Research results have been shared with apple growers around the country, via extension workshops and meetings, newsletters, and in one on one consultations.

Indiana apple growers have reduced their reliance on dangerous insecticides, which were targeted by the EPA as a leading source of potential risk to children's health. Purdue researchers conducted studies that tested less dangerous alternatives and have provided the results of those studies to apple growers through Extension programs. Several growers indicated they have changed their insecticide use for apple production. One large grower has switched from using organophosphate insecticides to using a much safer fermentation product. Another grower has adopted mating disruption for control of codling moth, eliminating the need for several organophosphate insecticide applications each season.