

# **Annual Report of Accomplishments And Results**

## **Agricultural Research Programs Purdue University**

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## **A. PLANNED PROGRAMS**

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

**Overview:** Sustainable crop and livestock production systems are important to Indiana agriculture. The economic value of agriculture in Indiana is approximately 2/3 plant based and 1/3 animal based. The challenge to farmers is to practice agricultural production in a way that is consistent with environmental quality while remaining competitive in a global market. Many new agricultural production technologies and systems are being developed by the public and private sectors. The challenge in a production system is to adapt and adopt those technologies that will serve in a given situation. While technologies and information are being developed to help farmers meet their challenges, creating or operating in a sustainable framework and applying new technologies and systems are really farmer dependent and adoption will vary greatly across a highly diverse landscape.

Genetics and biotechnology are providing a new frontier for agriculture, food, and forestry systems. To date, the genomes of higher plants, microbes and insects are known. The significance of understanding this blueprint for life is just now being realized with the discovery of the genetic basis for growth and development, and disease. Production agriculture will be transformed through the development of new genetic resources led by the field of genomics. Purdue research seeks to understand and exploit the genetic basis for plant, animal, microbial and insect form and function. Fundamental and applied research in genomics, molecular biology, and bioinformatics are the foundation for the development of value added/identity preserved green products. Discoveries in this area are increasing the profitability of producers by improving the productivity of crops and livestock, and adding value to the agricultural products.

Plant productivity is challenged by numerous biological and non-biological stresses. These stresses represent an annual economic risk to producers. Purdue agriculture is making a significant investment in research to mitigate the impact of potential losses by developing appropriate technology and systems. Pests adapt and evolve to counter control strategies, for example, the Western corn rootworm evolved to lay eggs in soybean fields thus causing problems in first year corn and negating rotation as a control measure. New pests, invasive species regularly enter agricultural systems, for example, the soybean aphid in 2000. Purdue researchers are exploring a variety of approaches to reduce potential pest loss including genetic resistance to pests, management on a wide area basis versus single field, modified production systems, biological control, chemical treatments, etc.

Regulatory developments are providing a significant challenge in developing pest management systems. The recent implementations of the Food Quality Protection Act has resulted in the cancellation of pesticides important in agricultural production. Also, public opinion and pending regulations by EPA on the use of transgenic methods to create plants that resist pests has placed another constraint on this approach to pest management.

Purdue scientists have been successful in several key pest management arenas, for example, developing wheat varieties that resist all major pathogens and the Hessian fly, developing apples with resistance to a primary pathogen (scab), identifying key planting time to evade insect infestation, creating predictive technology for critical application of pesticides, exploring biological control, etc.

Indiana animal producers are challenged every day to maintain a disease-free, well-cared for, and profitable herd or flock. It is not enough to ensure that livestock are protected from diseases; they must also be raised under conditions that minimize stress on the animal, maximize productivity, and are acceptable to consumers. Purdue is working to address each of these issues. Researchers have looked at the impacts of feed additives and vaccines in swine and cattle, studied best management practices, and investigated livestock animal welfare issues.

While agriculture is in a globally competitive situation it is also highly competitive at the producer and business level. Forces that are major contributors to the globally competitive position of U.S. agriculture include the development of new technology, business innovation, information as a resource, and capacity to adapt to change. The 1996 "Freedom to Farm Bill" provided new options for the producer. Both state and federal governments considered imposing additional constraints on producers through TMDL and FQPA, among other measures.

Timely information and communication become increasingly important as change occurs at an escalating pace. E-mail became a common media for communication of advisories. E-commerce became a serious business in agriculture. Consolidations and mergers became regular occurrences. Evolution of businesses, enhanced communication, and the emergence of precision farming technology have added yet another new dimension of complexity and opportunity for producers and agribusinesses. Competition and efficiency at the local level are the driving force behind a globally competitive system. Effective identification and use of technology and information management are key to being a player in the current environment. Studies have been conducted and information distributed that relate to and have impact on state and federal policy as well as the evaluation of different tactics and strategies for producer and business enterprises.

By enhancing the value and utility of agricultural and forest products, Purdue is providing Indiana farmers and businesses with opportunities to compete in new markets and obtain greater economic benefits. At the same time, many of the value-added products being developed for agriculture and forestry have environmental or nutritional benefits that, over the long run, will have a positive impact of the quality of life for all. Purdue research in this area seeks to create new uses for agricultural producers, while making more efficient use of natural resources and increasing the competitiveness of producers and agribusiness. One way this is being achieved is through the breeding or genetic modification of grain to make crops more valuable for food, processing, new materials, or energy production. Programs are also addressing ways to use agricultural carbohydrates and oils to make industrial products, such as plastics. Other researchers are looking for new uses of agricultural products and by-products as feed for livestock and fish.

#### **Successes:**

- Demonstrated economic benefit for paddock grazing system.  
Developed computer model pig rations correlated to pig life cycles that producers can use to realize economic benefits.  
Produced wheat varieties that resist primary pathogens.  
Identified economies of multiple components for precision agriculture.  
Benchmarked e-business availability, activity, and adoption in agriculture.  
Developed science based information that contributed to an improved regulatory approach for TDML.

Identified a gene that has implications for engineering plants to produce proteins and oils in their roots.

Identified a gene important for the production of scent in flowers.

Provided critical information leading to better decision-making regarding the risks of introducing GMO fish to natural populations.

Developed a soybean variety that is resistant to soybean cyst nematode.

Identified key genetic factors involved in muscle and fat development in food animals that will lead to leaner, healthier meat production.

Devised a process for incorporating inedible eggs into animal diets.

Developed a seed-to-seed tracking system to identify genetic purity.

Identified that after-sale service and cost are the two primary factors for producers in accessing e-business.

Surveyed growers and identified key elements in contract specialty grain production.

Developed a process that reduces cost of producing cyclodextrins.

Developed a soy-based diet for aquaculture species.

Designed a genetically modified cornstarch for specific process uses.

Found that a *Streptococcus suis* vaccine for swine was effective when administered to sows at 4 weeks and 1 week prior to farrowing.

Developed immunohistochemical and ELISA serology tests which provide accurate diagnosis of porcine type 2 circoviruses (PCV2) infection.

Found that conjugated linoleic acid (CLA) stimulated immune response in pigs when used as an alternative to animal feed antibiotics.

Determined that precision agricultural services that require significant capital outlays may not provide economic returns.

Identified components of a specialty grain production system that would provide economic benefits to growers.

Developed fertilizers formulated with metal chelators and micronutrients to improve disease resistance in wheat.

Demonstrated that the plant chemical osmotin induces fungal cell death and may be useful in genetic engineering of more fungus-resistant plants.

Developed a computer decision support model to help farmers analyze the economic impact of planting Bt corn on their farm.

Identified genes that encode winter-hardiness in wheat that are being used to breed winter-hardy varieties more quickly.

### **Benefits:**

Availability of a genetic purity tracking system that can run on an Excel spreadsheet.

Advisory information available to producers on contract growing, e-business issues, and organizational structures to enhance grower competitiveness.

Producers will be able to purchase Purdue-developed soybeans that are resistant to soybean cyst nematode by 2002.

Commercialized value added products with soybean base.

Soy based aquaculture diet will enhance soybean utilization.

Genetically modified corn starch requires less chemical processing thus reduces environmental impact.

Provided preliminary data for producers to establish an efficacious *S. suis* vaccination program.

Modified timing of vaccination of young pigs leading to more efficacious practice.  
Provided scientific data which led to the development of improved livestock waste management rules and regulations.  
A disease warning system for melon farmers has resulted in a 25% reduction in chemical fungicide use for a savings of \$250,000 in Southwestern Indiana in a single year.

### **State Assessment of Accomplishments:**

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

### **Resources:**

Approximately \$9,249,000 and 81 FTE have been invested in this Goal. This is a best estimate and these are not presented as auditable numbers.

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

#### **Key Theme: Grazing**

- a. *Description:* Purdue researchers conducted research on the potential merits of using variations in a rotational livestock stocking system. Most cow-calf producers currently use one large pasture with no rotation (continuous stocking). There is a question as to the benefits of subdividing a pasture into numerous paddocks for rotational stocking. They conducted research at two sites and found that an 8-paddock system produced 0.47 ton of hay per acre during the grazing season and 40 more grazing days in the autumn. Forage consumption by the cattle was not limited on any of the paddock systems.
- b. *Impact:* Value of the hay produced and extra grazing days in the autumn with an 8-paddock system is, conservatively estimated to result in a return of \$25 more per cow.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

#### **Key Theme: Animal Production Efficiency**

- a. *Description:* Fat and muscle tissue is of interest to animal producers because of its relationship to feed efficiency and meat quality. Improvement in meat-animal production efficiency requires a thorough understanding of the genetic and biochemical regulatory processes that regulate the growth of fat and muscle tissue. Research at Purdue has identified key factors regulating lean growth in pigs.

- b. *Impact:* Purdue researchers have shown that leptin, a growth factor produced in fat cells of mammals, serves as a major regulator of energy metabolism and immune response pathways in swine. Their work revealed that leptin stimulates fat metabolism, but as fat tissue increases the sensitivity to leptin diminishes, resulting in a reduced capacity to metabolize fat tissue. This decreased sensitivity to leptin was associated with increased blood levels of adiponectin in response to infection. These findings offer new insights into the relationship between animal health and lean muscle growth and will lead to new genetic and therapeutic technologies to enhance food animal production.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

**Key Theme: Animal Production Efficiency**

- a. *Description:* Pig weight gains in animal production systems have been highly variable. Studies have shown that different stages of the life cycle of the pig have significant differences in dietary requirements. Purdue researchers have developed a computer model that tailors diet and feed to growth stages and the type of pigs being raised. This growth model specifies a diet that gives producers the most profitable live weight growth, carcass compositions and feed conversion, and reduces nutrient excretion.
- b. *Impact:* A conservative estimate indicates that a producer can save \$1.50 per pig by using the computer model. Further, the diet generated by these tailored approach can also reduce the excretion of nitrogen and phosphorous. Information has been distributed to producer and commercial feed organizations.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

**Key Theme: Animal Production Efficiency**

- a. *Description:* Genetic evaluation and selection are necessary for continued improved performance of commercial crossbred pigs. Purdue researchers investigated the relationship among genetic improvement traits, and established a curvilinear economic value for leanness, and estimated the genetic trends for each trait in each breed. Their model shows, for example, that maternal line selection should focus heavily on reproductive performance and to a lesser extreme on postweaning performance. Terminal sire lines should emphasize postweaning performance traits. Pork quality traits are becoming increasingly important. Also, the rate of genetic improvement in sow productivity traits can be increased.

- b. *Impact:* The purebred associations have been utilizing this testing and genetic evaluation systems indexes (STAGES). Over 1.7 million performance records have been collected and analyzed by the STAGES evaluation system. This evaluation system has the potential to impact over 40% of the U.S. crossbred commercial pigs (35-40 million). Educational efforts have been directed towards seedstock producers to increase selection pressure on sow productivity in maternal lines. Educational materials have been developed and workshops and one-on-one discussions with breeders has been held. A new cooperative program has been initiated with breeders.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Animal Production Efficiency**

- a. *Description:* Corn hybrids have been genetically augmented using recombinant DNA technology to express proteins that provide agronomic advantages for corn growers. Purdue researchers investigated the potential impact on livestock growth and development. They fed silage and grain from either Bt-corn or from Roundup Ready® corn to lactating dairy cattle and compared the value of feeding these biotech corn hybrids with their near-isogenic counterpart non-DNA modified hybrids grown under identical field conditions. They fed lactating dairy cows diets containing up to 80% corn silage and corn grain from the respective corn sources to determine effects on feed intake, milk production, milk composition, and ruminal digestibility.
- b. *Impact:* The performance of cows fed genetically augmented corn was equivalent to cows fed conventional corn hybrids. The recombinant proteins were not detected in milk of cows fed biotech corns. There were no differences in milk production, milk composition, or ruminal digestibility for cows fed either Bt or Roundup Ready® corn compared with control hybrids. The data demonstrate equivalence of nutritional value and production efficiency for Bt and Roundup Ready® corn compared with the appropriate controls.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Innovative Farming Techniques**

- a. *Description:* Doublecropping soybeans following winter wheat is risky in the northern parts of states like Indiana, Ohio, and Illinois because wheat harvest is later, the growing season is short, and killing fall frost generally comes early. Winter wheat acreage has declined severely in the last decade (almost 50% in Indiana alone), in part because of the difficulty in getting sufficient income from a single crop of wheat relative to either corn or soybeans. A profitable second crop in the same year could help to restore winter wheat acreage and, with it, the additional benefits of winter soil erosion protection and crop diversification. Relay soybean production might be more successful if the seeds could be planted early, but if the seed emergence could be delayed until 3 to 4 weeks before wheat harvest. Polymer coatings on seeds, which are initially impermeable to water and therefore emerge later, would offer new potential for a relay cropping system. Suitable



biodegradable polymers for seed coating are now available. Purdue researchers established relay cropping trials involving wide-row (15") winter wheat at five locations in Indiana. Relay cropping resulted in much earlier maturity and higher yields than doublecropped soybeans at these locations. The overall profitability of the relay cropping system with coated soybean seed has the potential of being economically competitive with full-season corn and soybeans in soils with sufficient moisture availability. Forty farmers in nine states conducted pre-commercial field scale evaluations. Full farm-scale evaluations will occur in 2001.

- b. *Impact:* The opportunity to harvest two crops in one year in areas of the Corn Belt states traditionally unsuited to double cropping has generated media interest at local and national levels. Articles describing aspects of this novel cropping system have appeared in the *New York Times* (9-5-00), *Wall Street Journal* (8-26-99), *Indianapolis Star* (8-29-00), and several farm magazines. If this modified and prescriptive relay cropping system proves consistently profitable as indicated in early tests, it could assist resurgence in winter wheat acreage for states like Indiana. Relay cropping could provide important economic, environmental, and pest control benefits.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Precision Agriculture**

#### **FY '01 Focus: Sustainability of Agriculture and Forestry**

- a. *Description:* Precision farming technology promises to improve economic and environmental performance for crop production. By applying fertilizers and chemicals only where they are needed, instead of in uniform applications, precision farming can help reduce pollution. Agribusiness firms aggressively promote use of precision farming technologies, but many producers are hesitant about investing in precision farming because the profitability was unproven. Purdue researchers conducted on farm trials in NE Indiana to test the profitability of variable rate technology (VRT) for phosphate and potash fertilizer. The trials showed the VRT for these fertilizers was at best a break-even situation with current technology. A study of variable plant populations for corn showed that this technology was profitable mainly in areas where soils had yield potentials under 100 bu./a. In contrast, a study of VRT lime showed that this was frequently profitable in Indiana, because of the high variability of soil pH in the state. A study of GPS guidance showed that for producers who had already invested in GPS for yield monitoring, GPS guidance could be profitable solely through reduction in skips and overlaps in fertilizer and chemical production. The study also showed profitability of GPS guidance for custom operators. The researchers identified yield monitoring as key to profitable precision farming in grain crops.
- b. *Impact:* These studies were among the first to point out the low profitability of early grid sampling and variable rate fertilizer plans promoted by some dealers. This timely information helped producers and agribusinesses channel their precision farming investments to the more profitable technologies and/or to delay investments until profitability was more likely. The relatively slow adoption of technologies that were identified as low profit is one indicator of the impact of this work. In part because of the VRT lime study, this technology is becoming standard practice for many

Indiana farmers. The GPS guidance study helped provide the motivation to increase GPS guidance from 5% of custom operators in 1999, to 24% in 2000.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Multistate

## **1.B. Genetic Resource Development**

### **Key Theme: Plant Genomics**

a. *Description:* The genetic basis of plant development is poorly understood. The implications of understanding how plants grow and develop for production agriculture are significant. Purdue scientists are using a number of plant models to identify critical genes in the processes of growth and development. Using Arabidopsis as a genetic model, Purdue Scientists have identified the “PICKLE” gene, which plays a critical role in controlling the switch from embryonic to adult growth. The gene involved was found to be similar to genes that lead to a number of cancers in humans.

b. *Impact:* A biotechnology method was developed for producing plants with roots that produce protein and oils just like seeds normally do. Using the “PICKLE” gene from Arabidopsis, Purdue researchers are modifying root crops like turnips to produce high value oils.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Multistate

### **Key Theme: Ornamental/Green Agriculture**

a. *Description:* Improving floral scent is a goal of the \$20 billion US floriculture industry. As plants have been bred to maximize color, shape and other characteristics, the scents have often been overlooked. This leads many consumers of floral products to request heirloom varieties, where it is commonly held that scent is more prominent. Purdue researchers are exploring the molecular and biochemical basis for floral scent in snapdragon, an important commercial flower product. Studies have revealed that S-adenosyl-L-methionine benzoic acid carboxyl methyltransferase (BAMT) catalyzes the synthesis of methylbenzoate. This is a major component of snapdragon floral scent.

b. *Impact:* Identification of the key step in the production of volatile scent production in snapdragon will allow the engineering of plants to produce modified composition of volatiles. This will add value to flower crops. The introduction of novel scents and/or increased amounts of volatiles promises to improve crop production by maximizing pollination and yield.

c. *Source of Federal Funds:* Hatch

- d. *Scope of Impact:* Multistate

### **Key Theme: Risk Management**

- a. *Description:* The introduction of transgenic fish to open waterways has the potential to impact native populations through the transfer of genetic information. Assessing the risks associated with such a release are critical to evaluate the impact of a genetic engineered species prior to approval. A project at Purdue is using the Japanese fish medaka to examine what would happen if male medakas were modified with a growth hormone gene from Atlantic salmon and subsequently introduced to a wild population in a laboratory setting. The long term goal is to develop the science-based information upon which regulatory agencies can make decisions regarding the risks and benefits to genetically modified organisms.
- b. *Impact:* A model was developed to predict the outcome of releasing genetically altered fish into a native population of fish. Results from these experiments indicated that transgenic medaka's containing the salmon growth hormone gene were typically larger than native fish, making them more attractive to female mates. Also, the results showed that the fish carrying the growth hormone gene exhibited a reduction in the ability to survive. The model predicted that the spread of the transgene could bring a wild population to extinction in 40 generations. The results of this study provide critical information regarding potential risks associated with genetically modified fish. Long term goals of the project are to replicate these studies in larger fish of economic importance in a bigger environment.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Plant Germplasm**

- a. *Description:* The soybean cyst nematode (SCN) accounts for an estimated \$40M loss in soybean production in Indiana every year. Nationwide, the losses have been estimated at \$267M. Using races of cyst nematode that have been selected for virulence at Purdue University, scientists have identified plant genetic loci that confer resistance to all known races of soybean cyst nematode.
- b. *Impact:* Commercial soybean breeders have been unable to move soybean cyst nematode resistance from the poor performing Hartwig variety to more desirable cultivars. A method for tracking this resistance and facilitating the transfer to other varieties was developed at Purdue. This has created the CystX technology, which has been patent protected and licensed to commercial soybean

breeding companies. In test fields heavily infested with SCN, CystX more than doubles soybean yields. To date, CystX has been licensed to over 50 seed companies, with commercial seed expected to be available in 2002.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Multistate

### **Key Theme: Plant Germplasm**

#### **FY '01 Focus: Improved Pest Control and FQPA Implementation Sustainability of Agriculture and Forestry**

a. *Description:* Plant pathogens and insects have a significant impact on wheat and oat production annually in Indiana and surrounding regions. Development of varieties with resistance to these pathogens and insects would greatly reduce losses and would not impact the environment. Purdue researchers developed wheat and oat germplasm and varieties with resistance to the important pathogens and the insect pest Hessian fly.

b. *Impact:* Planting pest resistant germplasm should significantly reduce the 5% to 10% crop production losses annually. Plant resistance to pathogens and insects is a sustainable approach. Use of this germplasm reduces the potential need for pesticides and thus has an environmental benefit.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Multistate

### **1.C. Plant Stress Management**

#### **Key Theme: Plant Health**

a. *Description:* Researchers are looking at ways to increase the resistance of wheat to soil borne diseases, such as Rhizoctonia winter-kill, take-all root and crown rot, which reduce farmers' profitability and make wheat less attractive as a rotation crop in some parts of the Midwest. Studies conducted at research farms in Indiana looked at the impact of micronutrient deficiency on resistance to pathogens. They found that crops often cannot draw sufficient micronutrients from the soil to fend off diseases. Micronutrient fertilizers were formulated with natural chelators and tested for their ability to improve disease resistance in wheat. The researchers are also developing management practices for using nitrogen more efficiently while improving disease control and crop production.

b. *Impact:* By formulating fertilizers with chelators, researchers were able to make micronutrients more available for plant uptake for a longer period of time, while preventing soil microorganisms from tying them up. They found that they could increase wheat's disease resistance by making micronutrient fertilizers more available in soil. Approximately 50 thousand of the 700 thousand acres of wheat planted in Indiana are not harvested each year because of Rhizoctonia winter-kill, resulting in a loss of \$10 million in income. Farmers who follow the new recommendations could

reduce these losses, as well as losses from other soilborne diseases. This would allow farmers to use wheat in their rotation and make them more competitive in today's global market.

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

### **Key Theme: Plant Health**

- a. *Description:* A Purdue scientist is studying compounds that are naturally produced by plants to fight fungal pathogens. This researcher has identified one of these compounds, osmotin, and has investigated its mode of action in yeast.
- b. *Impact:* This research has shown that osmotin fights fungal pathogens by tearing holes in cell membranes while altering the protein-generating machinery of the fungal cells, causing the fungus to build weaker walls. Osmotin effectively induced apoptosis, or programmed cell death, in yeast. Plant diseases—many of them fungal diseases—still cause more than \$9 billion in annual losses in the United States. Knowledge of the genes that encode osmotin could potentially be used to genetically modify plants with greater resistance to fungal diseases and lead to reduced fungicide use.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Plant Production Efficiency**

- a. *Description:* To avoid significant losses from plant diseases, muskmelon and watermelon farmers typically spray protective fungicides once a week for two months during rapid vine growth, fruit development and melon harvest, regardless of actual weather-related disease threat. Purdue researchers have developed the MELCAST disease warning system, which enables farmers to reduce the frequency of their fungicide applications. MELCAST uses hourly weather data to index each day's favorability for disease development. When the environmental favorability index, or EFI, reaches a predetermined threshold, a spray is advised. Instead of spraying every seven days, regardless of a disease threat, fungicides are applied at prescribed EFI intervals.
- b. *Impact:* On farms using the MELCAST system for a period of 4 years, two to three fewer sprays were applied per season, with no increase in disease risk. This represents at least a 25%, or approximately 10-ton reduction, in chemical fungicide applications and translates into a savings of nearly \$250,000 for Southwestern Indiana farmers in a single year. This system is being tested in other states.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Indiana

## **Key Theme: Agricultural Competitiveness**

- a. *Description:* European corn borers cause \$1-\$2 billion annually in economic losses. Since 1996, U.S. farmers have begun to adopt genetically engineered corn (Bt corn) to control the European corn borer. For the 2000 crop year, 19% of the U.S. corn acreage was planted to Bt corn. A study at Purdue focused on the economic implications of farmer adoption of Bt corn and the costs associated with compliance with EPA's 20% refuge requirement. Data were collected from Kansas, Iowa, Illinois, and Indiana on corn borer infestation levels and yield losses. These four states represent about one-half total U.S. corn production. A computer-based decision tree model was developed to calculate the expected benefits and costs of corn borer infestations taking into account the probabilities of each of three generations per growing season and the expected associated physiological and mechanical damage.
- b. *Impact:* The researchers found that the adoption of Bt corn is not economically viable for most Indiana farmers since the probability of European corn borer infestations that might cause economic damage is less than one out of every four years. However, in Southwest Kansas, Bt corn is a very attractive alternative to normal insecticide control programs. If farmers adopt Bt corn, they must plant a 20% refuge, at a 2-3% per acre increase in cost. This decision tree may prove very useful to farmers looking to assess the economic risks of planting Bt and other genetically engineered crops.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

## **Key Theme: Plant Production Efficiency**

- a. *Description:* Poor winter survival is a key problem limiting alfalfa production in the North Central United States. In the past, alfalfa breeders used traditional methods to select for yield and stress tolerance in alfalfa. They have lacked knowledge of traits and genes controlling winter hardiness that could help them more quickly improve alfalfa varieties. Purdue researchers recently identified genes closely linked to alfalfa's ability to survive winter weather.
- b. *Impact:* Using the Purdue-discovered genes, breeders will be able to identify winter-hardy alfalfa in one year with one test, rather than having to test plants from 10 or 15 locations over four years. As a result, farmers will soon have reasonably priced, winter-hardy alfalfa cultivars that can live six years, rather than the usual three or four. This will save them the time and the \$400/acre that it costs to re-seed a field of winter-killed alfalfa.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

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

### **Key Theme: Animal Health**

- a. *Description:* Purdue researchers have investigated the efficacy of vaccination protocols recommended for *Mycoplasma hyopneumoniae* in swine. In some herds, these vaccines have failed when used according to the manufacturers label. Researchers evaluated the influence of colostral antibodies (natural and vaccine induced) on the efficacy of a mycoplasmal vaccine used according to the label and at alternate ages.
- b. *Impact:* Researchers found that natural and vaccine-induced colostral antibodies interfere with the immune response from vaccine administered to pigs at 1 and 3 weeks of age. They detected minimal natural or vaccine-induced interference when pigs were vaccinated at 6 and 8 weeks of age. Additionally, the average lung lesion score in challenged pigs appeared to be lessened in pigs vaccinated at 6 and 8 weeks. Results indicate that swine producers that are using *Mycoplasma hyopneumoniae* vaccines should consider vaccinating pigs when they are 6 to 8 weeks old or possibly older if they noted poor response to their current vaccination scheme.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Animal Health**

- a. *Description:* Purdue researchers investigated protocols and methods of animal vaccination for both pigs and cattle. They are looking at the timing involved in vaccinations and the method by which vaccines are introduced to the animal. They are validating efficacious vaccination protocols for *Streptococcus suis* in swine. The goal of this study is to determine when the *S. suis* bacterin should be given to sows prior to farrowing. Another study is comparing intranasal, oral, and injection methods of vaccination and their effects on bovine immune response. The objective of this project is to find a more effective means by which to immunize cattle against respiratory disease.
- b. *Impact:* The *Streptococcus suis* vaccine for swine was found to be effective when administered to sows at 4 weeks and 1 week prior to farrowing. This study provided preliminary data for producers to establish an efficacious *S. suis* vaccination program. Data from another study indicate that vaccines targeted to the tonsils would offer both mucosal and systemic immunity. This was supported by the finding that vaccines administered intranasally, but not orally, induced systemic and mucosal antibodies. New vaccines that are targeted to the tonsils will induce a strong protective immune response in the upper respiratory tract and will greatly reduce the incidence of respiratory infections.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Animal Production Efficiency**

- a. *Description:* Food animal well-being has become an issue with consumers and businesses. Research at Purdue is providing science-based information on sound livestock handling practices, for example, as it relates to animal aggressive behavior, housing systems, etc. Researchers found that when given the freedom to move out of their pens, most sows chose to spend time away from the piglets for long periods of time. Piglets kept in “get-away pens” were better prepared for the eventual weaning and separation from the sow. Other Purdue researchers used a genetic method of “group selection” to develop a line of kinder, gentler chickens that do not peck each other. Adopting this genetic line means the chickens can keep their long beaks, rather than have them trimmed.
- b. *Impact:* Producers in the animal system have been informed about the findings. Some large producers and an industry chicken products user are attempting to use the “gentler chicken” and eliminate the debeaking practice. Broad producer testing is needed to determine impact of the above practices.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

#### **Key Theme: Animal Health**

- a. *Description:* Turkey poult infected with turkey coronavirus (TCV) cause acute enteritis, mortality, and decreased weight gain. Currently, no effective medication or vaccination is available for the control and prevention of the disease. Purdue researchers developed an antibody-capture enzyme-linked immunosorbent assay (ELISA) for detection of antibody to TCV utilizing infectious bronchitis virus (IBV) antigen. They successfully used commercially available ELISA plates coated with IBV antigens. They evaluated the performance of the ELISA system by 45 normal turkey sera and 325 turkey sera from the field.
- b. *Impact:* Large quantity of turkey serum samples from the field (acute outbreaks, recovery flocks, or routine health monitoring) can be handled by ELISA with rapidity and precision. Thus, this assay provides an efficient and cost-effective way for diagnosis and control of turkey poult enteritis and benefits the turkey farmers. Turkey poult enteritis has contributed to significant economic loss in the turkey industry in Indiana, North Carolina, and other states. Reliable tests for diagnosis will be a first step toward control and eradication of this disease.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

#### **Key Theme: Emerging Infectious Diseases**

- a. *Description:* New porcine type 2 circoviruses (PCV2) have recently been described in swine and are associated with a post-weaning multisystemic wasting syndrome (PMWS). Porcine circoviruses of unknown genetic type have previously been associated with congenital tremors (CT) in swine. Methods of prevention or control for PCV2-induced diseases do not exist. The goal of Purdue scientists is to develop an accurate method for diagnosing the disease in pigs. They investigated



PCR, in-situ hybridization, immunohistology and serology as possible methods for detection of PCV2 in porcine samples. Using these tests as well as conventional pathology and other diagnostic tests, they studied numerous pigs with PMWS from swine farms throughout the mid-western United States.

- b. *Impact:* Purdue researchers developed PCR, in-situ hybridization, immunohistochemical, ELISA serology, and IFA serology tests. Results from the pig studies confirmed a close association of PCV2 with lesions of PMWS, confirmed macrophages and epithelial cells as the predominant cells infected by PCV, and demonstrated a consistent dual infection by PCV2 with porcine adenovirus or PRRS virus. These efforts have allowed for accurate diagnose of PCV2 infection and related diseases.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

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

### **Key Theme: Precision Agriculture**

- a. *Description:* Tracking grains to identify genetic purity and composition has become increasingly important. Purdue researchers have developed a computer-based program that can run on an Excel spreadsheet. The system is based on laboratory tests, and field and bin inspections. Data from these sources provide the basis for estimating the purity of harvested grain. This program facilitates tracking purity from seed to seed.
- b. *Impact:* This system can be used by farmers, seedsman, or processor. There are numerous potential uses for this system including quality assurance, facilitate marketing value added/specialty grains, and reducing the potential for “genetic contamination”.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Agricultural Competitiveness**

- a. *Description:* E-business is a relatively recent, but rapidly expanding, way of doing business, particularly for the input side of agricultural production. Farmers have rapidly adopted the internet as a business management tool. Agribusiness firms are formulating e-business strategies in anticipation of lowering their cost of serving farmers, or increasing the value they can bring farmers. Purdue researchers conducted a major survey on adoption of e-business practices by U.S. agribusiness firms.
- b. *Impact:* Key findings suggest that e-business transactions currently account for a very small proportion of the total transaction volume of agricultural input firms. However, the volume is expected to grow rapidly in the next 3 years. Manufacturers and larger firms are most positive about e-business prospects relative to dealers and smaller firms. After-sale service is the most important

barrier to expansion of e-business. A lower price for products is the most important facilitator of e-business transactions. This study provides the critical base benchmark for e-business development. It can/will serve as a significant resource for businesses considering engaging in agricultural e-business. Information has been distributed through a conference, numerous presentations and interviews, and professional papers.

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

### **Key Theme: Precision Agriculture**

- a. *Description:* Precision agricultural businesses include a wide variety of services and technologies for the site-specific management of agricultural production. Services range from soil sampling using global position systems to variable rate application of fertilizer. Purdue researchers have tracked adoption of precision agriculture for a number of important reasons, including determining which services appear to be capable of generating a return for producers and disseminating information on the service bundles and pricing programs that are most prevalent in the marketplace.
- b. *Impact:* Results of surveys suggest that expansion of site-specific service offerings have slowed in 1999. Dealerships continue to focus more 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 continue to be slower, but modest growth does continue. Pricing programs for these services are highly variable. There are a higher number of service providers in the Midwest than in other states. The most prevalent approach to providing farmer services is through cooperatives and larger national organizations rather than through independent operations. Implications suggest that many growers will ultimately have a number of possible sources of precision services to evaluate and that there will likely be considerable difference in both the services included in the bundle and in the price of the bundle. Producers will need to carefully evaluate the specific value of the services they are considering, and focus on both near and long term benefits of any specific package. The information developed by Purdue researchers will provide a basis for decision by both producers and service providers on the cost effectiveness of various services as a part of the overall production system.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Agricultural Competitiveness**

- a. *Description:* Various existing and proposed regulations at the state and federal levels influence profitability of livestock farms and the function of markets. For example, both state and federal regulatory agencies have proposed more rigorous livestock waste disposal regulations. In addition, recent consolidation in the animal slaughter industries has increased concern about market power and marked down live animal prices. Purdue researchers have estimated the impact of proposed phosphorus application rate restrictions on Midwestern hog and dairy farm profits. They found that

such restrictions could result in significantly lower profits to hog farms, but will not likely have an impact on dairy farm profits. In the potential for hog production cooperatives, there is potential for cooperative risk sharing between risk-averse cooperative membership and a risk-neutral packer. They also showed that producers and producer cooperatives would be advised to postpone consideration of investment in a packing plant. The irreversibility of such an investment coupled with the uncertainty in hog and feed prices results in a sizeable risk.

- b. *Impact:* Purdue researchers worked with subcontractors, EPA, IDEM officials, producer groups, and staff at the Indiana Commissioner of Agriculture to improve estimates of the impacts of proposed livestock waste regulation. These efforts also led to more realistic regulations at the state level. Testimony before the U.S. Senate Committee on Agriculture, Forestry, and Nutrition led to greater public awareness of the potential for market power in the pork packing industry. Previously, most attention had been focused on the beef packing industry. This initiative also shed light on the potential for producers to countervail market power via cooperatives.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Agricultural Competitiveness**

- a. *Description:* Emergence of new products and markets as well as changing market organizations are challenging the grain and oilseed industry. Purdue researchers have surveyed 8,000 Indiana specialty grain and oilseed producers. This database has been used to describe the commodities and systems of specialty grain production in the state. Their study seeks to answer questions such as: How much value is inherent in value-added grain productions? Is value-added grain production riskier than traditional cash grain productions? How does contract production of value-added grains differ from traditional cash grain production? Among the outputs are an evaluation of risk mitigation, risk absorption, and risk reduction strategies, and a delineation of the role and impact of production contracts as a coordinating mechanism in the grain industry.
- b. *Impact:* Risk assessment results will assist in the design and successful use of crop production contracts, as well as the effectiveness of yield insurance, revenue insurance, and price risk management tools. Survey results have heightened awareness and highlighted constituents' needs for information on specialty grain production in Indiana and the U.S. Corn Belt.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **1.F. Value-Added**

#### **Key Theme: Adding Value to New and Old Agricultural Products**

- a. *Description:* To expand uses and give carbohydrates more valuable properties, knowledge of structures, structure-function relationships, and the effects of structural modifications on properties

are essential. Both basic research scientists and industrialists are looking for ways to make improved, value-added corn starch products without violating restrictions on the types and amounts of chemical reagents that are employed in starch development. A project at Purdue is looking at ways to modify starch within the granule and on starch polymers. Purdue researchers developed a method that can be used to follow modification reactions both within starch granules and on the starch polymer molecules.

- b. *Impact:* Results generated by this study are being used in attempts to make improved, higher-value corn starch products for use as food ingredients, in wet-end and sizing operations in the papermaking industry, and in other applications.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

**Key Theme: Adding Value to New and Old Agricultural Products**

**FY'01 Focus: Biobased Products Program**

- a. *Description:* Declining petroleum reserves and increasing prices combined with the need for sound environmental stewardship have spurred new efforts to utilize renewable agricultural carbohydrates and oils as sources of energy and raw materials for industrial and consumer products. Purdue researchers are focusing on understanding the physical and chemical properties of these renewable materials with the long-term objective of developing new materials for the production of industrial and consumer materials and energy. They have conducted studies to elucidate the mechanism, action, and production of the cyclodextrin glycosyltransferase (CGTase), an enzyme that is important for the production of cyclodextrin.
- b. *Impact:* Results from this research will decrease the production costs in making cyclodextrins, giving them wider application in a host of value-added products, thereby increasing the utilization of starch. Additionally, discoveries of more sensitive detection methods for CGTases provide more effective research tools for exploring cyclodextrin synthesis and recombinant genetic production.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

**Key Theme: Adding Value to New and Old Agricultural Products**

**FY'01 Focus: Biobased Products Program**

- a. *Description:* Purdue researchers are studying inedible eggs, which constitute about 2% of total production, as a valuable feed ingredient for swine and poultry. Current research is looking at the eggs as a rich source of immune globulins for early weaned pigs. Another project is developing corn and soybean-based feeds for farm-raised fish to replace the more expensive fishmeal typically used. Purdue researchers are testing grain-based diets formulated for yellow perch, trout and lobster, all important commercial species, have been tested in laboratory-scale operations.

- b. *Impact:* Eggs that were previously deemed inedible because of rejection in the candling process now are being marketed as a high energy, rich protein ingredient for young pigs. They have particular potential in diets for early weaned pigs. Fish that eat soy-based feeds have been shown to excrete less phosphorus and nitrogen than fish that are fed fish meal. The finding about feeding fish soy-based diet has important environmental implications since phosphorus and nitrogen are common water contaminants. The yellow perch diet is now commercially available to producers.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

**Key Theme: Adding Value to New and Old Agricultural Products**

- a. *Description:* Starches derived from corn or other crops are important for food, paper, and other industries. Through genetic modification, specialty starch corn varieties can be developed that will provide a more "natural starch" having the same or similar functionalities now only possible with chemically modified or enzyme-modified starches. Purdue researchers are focusing on genetics and breeding for modifications of corn endosperm starches, with emphasis on selection for unique starch structural and functional properties that will enhance utilization of corn for food and non-food uses. They developed lines of both yellow and white endosperm corn with single and multiple starch mutant characteristics and evaluated them for agronomic performance.
- b. *Impact:* Industry is currently using several of the new specialty starch corn strains developed at Purdue in their operations. Development and use of genetically modified starches possessing unique properties isolated from either single or combinations of endosperm starch mutants offer an alternative way to improve performance characteristics and add value to the grain. Their use as a replacement for starch that is chemically modified will have definite positive effects on the environment, energy consumption, worker safety, consumer acceptance, and economics of the wet milling industry. Furthermore, the new specialty strains of corn will command a premium price for the farmer-producer of the grain, as well as for the wet-milling industry-producer of the specialty starches.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

**Key Theme: Adding Value to New and Old Agricultural Products**  
**FY'01 Focus: Biobased Products Program**

- a. *Description:* A Purdue researcher is investigating the genetic modification of lignin content in plants. The goal is to understand key factors that determine the quality and quantity of lignin in plants and ultimately to address this economically important issue by the directed manipulation of

lignification. The researcher is using the model organism *Arabidopsis* to characterize an enzyme, p-coumarate 3-hydroxylase (C3H), that is an important step in lignin synthesis.

- b. *Impact:* A gene in *Arabidopsis* has been identified, cloned, and shown to encode the C3H enzyme. A mutation in this gene results in changes to plant cell wall lignin content that, if translated to crop species, would be of significant benefit to agriculture. There is a great deal of evidence that the modification of lignin biosynthesis improves forage digestibility and could improve the efficiency of saccharification of the lignocellulosic materials used for bio-ethanol production.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

## **GOAL 2: SAFE AND SECURE FOOD AND FIBER SYSTEM**

**Overview:** As we enter the new millennium, we are faced with tremendous challenges and opportunities related to improving the safety and quality of our food supply. The Hazard Analysis Critical Control Point principles, used to identify and control hazards using a farm to fork approach, has demanded attention. Quality management for microbial and chemical hazards affecting product shelf-life is using similar approaches. Certain food groups also should receive special attention. Potentially hazardous foods, especially those originated from an animal source (such as seafood, meat, poultry, and dairy products) deserve attention because they can support the rapid and progressive growth of microbes and spoilage hazards. Fruit and vegetable products and ready-to-eat processed foods have also received attention. Because many fruit and vegetable products are presented to the consumer in raw form and will not be cooked, detection and control is important in all areas of growing, harvesting, processing, and delivery to consumers. Ready-to-eat processed foods, such as dairy products and processed meats, pose the greatest risk during processing operations. Better control and better means of detection for hazards are needed. Emerging pathogens, such as *Listeria monocytogenes* and *E. coli* O157:H7, present challenges due to low infective dose requirements for disease, difficulty in detection, and resistance to environmental stresses.

Using a multidisciplinary effort, Purdue scientists combine research and outreach strengths built teams to study potential safety issues from production through consumption. Their focus is to gain a better understanding of food safety and quality hazards by developing better methods of control and detection for all areas of food production. On farm efforts have focused mainly on the pork industry, the fruit and vegetable industry, and the seafood industry.

Purdue researchers are studying the biochemical processes of the conversion of muscle to meat. Studying components of biochemical processes and substrate utilization makes it possible to better estimate meat quality from the farm to the slaughtering process. There has also been a long-term concern for plant materials used as animal and human feed. Aflatoxin-producing molds continue to raise concern due to their potential cancer causing attributes. Purdue researchers are sequencing the genetic code to better understand those factors that are involved in the production of toxic substances. This is the first step, and perhaps most important step, in developing control mechanisms to prevent or reduce expression of genes leading to aflatoxin production.

Purdue researchers have developed a method using nuclear magnetic resonance to nondestructively evaluate the quality of fruit and vegetable products on the farm. This new method of detecting quality factors will help farmers understand how to better grow plant products and determine the best time for harvesting crops.

The production of aquaculture products is gaining more interest, especially for states that have limited capabilities to harvest seafood products. Chemical contaminants from fishery products are an important identified hazard. Purdue researchers have developed a better and more rapid method to measure chemical contaminants of concern in aquaculture products. The immunosorbant assay based test not only helps in detection, but it is also used to determine the effect of processing on chemical load. Pre-and post-treatment evaluation for cooking, frying, and smoking operations show the effect of each preparation method.

In food processing operations, Purdue researchers are developing and evaluating several methods for control and reduction of pathogens and spoilage organisms. Non-thermal treatments are gaining popularity because they may reduce microbial contaminate levels while maintaining product quality. Purdue researchers are using UV light during the meat ageing process to reduce microbial levels of *Salmonella* and *E. coli* on pork carcasses. Pork is an important commodity in Indiana. This species serves as a model and the technology should be suitable for other species.

Purdue researchers are using ozone and chlorine dioxide gases for potential use on raw fruit and vegetable products. Optimized processes for both gas treatments have resulted in significant microbial reduction far exceeding current methods. The process should be applicable for all fruit and vegetables of concern, including fruits, fruit juices, sprouts, leafy vegetables, berries, and melons.

The storage requirements and consumer cooking recommendations for whole shell eggs have recently changed due to the potential presence of *Salmonella enteritidis* bacteria. The organism is found in approximately 1% of whole shell eggs and is extremely dangerous for the immuno-compromised host. Purdue researchers have developed a series of thermal processing strategies to treat whole shell eggs and eliminate *Salmonella enteritidis*. This represents a significant development, especially for institutional feeding operations such as hospitals, daycares, and nursing homes that serve at-risk individuals. The process also creates a value-added product that can be sold and marketed at a premium price.

Packaging of processed products is also an important consideration in food safety. Purdue researchers are investigating further anti-microbial effects for foods in the package. They are incorporating anti-yeast and mold components into food packing materials to increase product shelf-life.

Purdue researchers are studying a value-added process for cheese manufacturing using whey proteins and plasmin, which are generally less usable by-products. Other Purdue researchers are developing “smart sensors.” These sensors measure quality parameters and optimize food processing and storage conditions.

In addition to the research activities above, Purdue is establishing two campus-wide research centers. The first center, the Center for Enhancing Foods to Protect Health, is related to food safety and human nutrition. The focus of this effort is to understand the impact of food ingredients on human health, emphasizing nutraceuticals and functional food groups. Another center, the Food Safety Engineering Project, is in the early stages and will engage the combined effort of five schools to conduct food safety engineering research. The Food Safety Engineering Project is a joint effort between the USDA Agricultural Research Service (ARS) and the School of

Agriculture at Purdue University. The mission is to develop new knowledge, technologies, and systems to prevent chemical and microbial contamination of foods.

**Successes:**

Developed edible packaging films that inhibit yeast and mold growth.

Two major research centers have been developed to focus on a) microbial and chemical detection and on b) human nutrition.

Developed test kit for rapid assay of insecticide in fish.

Identified genes of aflatoxin produced by *Aspergillus* mold.

Developed non-thermal antimicrobial processing strategies to help processors meet and exceed microbial standards, resulting in products that have an extended shelf-life.

Modified poultry diet to produce eggs with increased beneficial fats linked to lowering cancer and cardiovascular disease rate.

**Benefits:**

Development of research centers at Purdue raises the level of technology development and knowledge transfer within the state, nationally, and internationally.

Non-thermal practices can be applied in small food companies so the company will remain viable and competitive.

**State Assessment of Accomplishments:**

Indiana's food safety and quality needs relate to the types of products that are produced in the state and the size of the food companies growing, processing, and preparing food products. Purdue researchers have clearly addressed priority needs and concerns of the people and businesses in Indiana, including small operators of the pork and fruit and vegetable industry. They have developed control and detection strategies that will help Indiana based agriculture compete and have a national impact.

**Resources:**

Approximately \$291,000 and 3 FTE have been invested in the Goal. This is a best estimate and these are not presented as auditable numbers.

**Key Theme: Foodborne Pathogen Protection**

- a. *Description:* A multi-disciplinary group of Purdue researchers is in the early research stages of developing a new electronic sensor to detect *Listeria monocytogenes* in foods. The test will detect very low levels of the organism rapidly and accurately in a one gram or one milliliter sample size of food. The project involves the development of a biochip that detects specific antibodies from *Listeria monocytogenes*. Living and dead cells can be detected using the method. The overall goal is to build an engineering platform that can be used to detect a wide variety of microbial or chemical hazards of interest in foods. Another multi-disciplinary team of Purdue researchers is investigating a different approach for detection of *Listeria monocytogenes*. They have developed an antibody coupled fiber optic probe using an electric chip and a spectrofluorimeter-based assay to detect the organism in food. It can be used to study the interaction of the organism with human and animal cells.



- b. *Impact: Listeria monocytogenes* represents a significant public health concern. USDA-FSIS estimates a 20% death rate for those individuals infected with the disease. Recent risk analysis data shows that *Listeria monocytogenes* is very common to foods and is found in many ready-to-eat foods at rates of 1-10%. Rapid and accurate detection of *Listeria monocytogenes*, especially in ready-to-eat foods, will help reduce risk and save lives. It may also help provide important information to determine the source of contamination and effective means of control. It will also greatly reduce the time for microbial analysis and may reduce economic losses.
- c. *Source of Federal Funds: Hatch*
- d. *Scope of Impact: Multistate*

### **Key Theme: Food Safety**

- a. *Description:* In a 3-year, 8-state cooperative study, Purdue researchers have surveyed channel catfish, rainbow trout, and red swamp crawfish from aquaculture operations for 34 organochlorine, organophosphates, and pyrethroid compounds. A rapid test kit was developed using an immunosorbant platform. They found no detectable residues in 45% of catfish, 73% of trout, and 92% of crawfish. They found that frying, baking, and smoking reduced residue levels on positive samples, with frying being the most effective method.
- b. *Impact:* The development of a rapid assay for measuring chlorpyrifos in fish tissue will enable producers and processors to screen their products before sale to consumers. Understanding the influence of cooking on contaminant level will allow health professionals to better estimate the risk to consumers of contaminated fish when developing consumption advisories.
- c. *Source of Federal Funds: Hatch*
- d. *Scope of Impact: Multistate*

### **Key Theme: Foodborne Pathogen Protection**

- a. *Description:* New regulations and microbial standards in the meat and poultry industry have been implemented for *Salmonella* and *E. coli* bacteria. A team of Purdue researchers developed a process that uses UV light to decrease *Salmonella*, *E. coli* and spoilage organisms present on pork carcasses used during cold storage carcass aging.

Purdue researchers have evaluated alternative non-thermal processing methods to reduce pathogens on fruit and vegetable products. The use of chlorine dioxide (ClO<sub>2</sub>) gas has showed the most promise. ClO<sub>2</sub> treated *E. coli* O157:H7 on green peppers has resulted in a log reduction of up to 6.45 after exposure to 1.24 mg/l ClO<sub>2</sub>, for 30 min at 22°C and 90-95% relative humidity. In contrast, water washing achieved log reductions of only 1.5 to 2.5. This novel means of processing

fruits and vegetables results in over a 1000-fold greater pathogen reduction compared to traditional washing.

Purdue researchers have developed a process to reduce the risk of *Salmonella enteritidis* in whole shell eggs. The process involves a low-temperature, long-time, heating pasteurization process to kill *Salmonella* in whole shell eggs without causing quality defects or egg protein coagulation.

Purdue researchers developed a new type of food packaging material to provide protection and increase the shelf-life of fruits and vegetables. Edible films containing whey and potassium sorbate are the key components in the formulation of the antimicrobial film. The films have been shown to inhibit the growth of yeast and molds on the surface of foods thus enhancing the shelf-life.

- b. *Impact:* The application and implementation of each of the processing and packaging strategies developed at Purdue reduce the risk of foodborne pathogens. Specifically, the UV treatment provides a treatment option for small and very small pork slaughtering operations so that their products can be competitive. The new process also helps processors keep within the limited microbial standards established by USDA. Reducing pathogens on the surfaces of fruit and vegetable products will likely have a tremendous impact on risk reduction and increased shelf-life. Newly mandated regulations for fresh fruit juices require at least a 5-log reduction in pathogens. This new process can achieve well in excess of the 5-log reduction while maintaining fruit quality. The pathogen reduction process for whole shell eggs significantly reduces risks for the immunocompromised populations including infants and the elderly. Within the state of Indiana, if 10% of the 4 billion shell egg business were incorporated into the value-added pasteurized product, egg producers estimate a \$40 million increase to the state economy.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Food Quality**

- a. *Description:* Production practices have been improved for animal agriculture. Quality of meat can be affected by growth, nutrition, metabolism, and carcass handling/processing. Purdue researchers have developed a carcass stimulation model to study the control of energy utilization (glucose, glycogen, lactate, and glucose 6-phosphate) in postmortem muscle. Of particular interest was the transformation of muscle into meat with regard to the role of glucose 6-phosphate. Glucose 6-phosphate decreased early in postmortem, and after 60 minutes, glucose 6-phosphate increased. This information could be correlated with meat quality.
- b. *Impact:* Understanding the biochemical processes that cause antagonism between muscle growth and meat quality will help the industry develop selection and management strategies to overcome obstacles and enhance the delivery of quality meat products.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Food Safety**

- a. *Description:* Purdue researchers are working to understand the genetic makeup of cancer causing mycotoxins. Specifically, they have identified and marked genes of aflatoxins produced by the *Aspergillus* mold.
- b. *Impact:* Understanding the genetic components involved in aflatoxin biosynthesis will give insight into how the biosynthesis of aflatoxin can be repressed. This will reduce risk and increase economic profit.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Food Quality**

- a. *Description:* Purdue researchers have investigated nondestructive testing of plant materials a means to better estimate the quality of foods. Laboratory tests have demonstrated that magnetic resonance sensing can be used to rapidly and nondestructively evaluate several quality attributes. The technology can be used to evaluate the potential for browning of whole apples and is also being used to monitor the moisture content of processed cheeses. Purdue researchers have adapted a magnetic resonance sensor that can be used to test samples of food products placed in 25 mm glass bottles.
- b. *Impact:* If this technology can be adapted from the laboratory to an on-line commercial operation, it will enhance the potential to provide the public with an enhanced quality product.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Food Quality**

- a. *Description:* Purdue researchers are studying quality improvement in food processing operations. In an effort to increase the yield of cheese from milk and to increase the rate of cheese ripening, they added whey protein concentrates with different levels of plasma to cheddar cheese curds during ripening. Initial results show that some whey proteins and plasma have been incorporated into the cheese curd and have resulted in an acceptable end product.
- b. *Impact:* Incorporation of whey proteins and plasmin into cheese curd will influence cheese yield, increase cheese ripening, and reduce cheese production costs.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

## **Key Theme: Food Handling**

- a. *Description:* Purdue researchers are using advanced computer technology to: 1) develop smart sensors that measure quality of food as it is produced, 2) develop models to simulate and better understand the behavior of foods as they are processed, 3) develop control strategies that allow for flexibility in manufacturing, and 4) integrate processing information with other manufacturing areas such as quality control, purchasing, planning, and warehousing/distribution.
- b. *Impact:* A California-based tomato processor has been able to improve quality and productivity by using a new, Purdue-developed sensor that measures the consistency of tomato sauce. Initial results show that the new sensor can save a processor up to \$300,000 annually by reducing waste and labor costs associated with traditional methods. Using computer systems in food manufacturing systems like this one will help U.S. food manufacturers provide safe, high-quality, value-added products at low cost.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

## **GOAL 3. A HEALTHY, WELL NOURISHED POPULATION**

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

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

Purdue researchers have focused on both identifying and correcting deficiencies in essential nutrients such as calcium, and on lowering risks of disease through the use of dietary supplements. For example, they investigated the role of vitamin D and sphingolipids in the regulation of cell growth and death during strokes and stages of cancer. Purdue work suggests that dietary recommendations for these nutrients can be made that may prevent or minimize damage caused by these devastating diseases. Other Purdue researchers have looked at the effects of consumption of green tea on cancer cells. They have shown that a compound in green tea

called EGCg can inhibit the cancer cells' ability to produce tNOX enzyme, thereby effectively stopping their growth. This work has shown that drinking more than four cups of green tea a day can slow or prevent the growth of cancer cells.

The increasing popularity of dietary supplements and nutraceuticals has opened new opportunities for research in the development of new foods with added nutritional or medicinal benefits. New traits can be introduced through either the engineering of raw materials or the formulation of a finished food product. Purdue research on the food additive inulin has shown that, in addition to being a sugar and partial-fat substitute, and a source of soluble fiber and safe for diabetic use, it can extend the shelf life of baked goods. Purdue researchers have also shown it is possible to fine tune chicken feed with the addition of supplements to produce eggs that contain more of two beneficial fatty acids. These fatty acids can help reduce the risk of cancer and cardiovascular disease. Purdue researchers have identified the genes in oats that regulate the production of beta-D-glucan, the compound in oat bran that lowers blood cholesterol levels and moderates insulin demand in diabetics. The discovery of the genes responsible for its synthesis may make it possible to genetically engineer rice and corn that can help lower blood cholesterol.

Through understanding the fundamental mechanisms that control certain cell functions, such as division, new targets for pharmaceuticals, gene therapies, and antimicrobials can be identified. Purdue researchers have advanced the fundamental understanding of proteins and genes that could ultimately lead to the development of new drugs to treat a variety of diseases. They have identified several important cell components and biochemical processes. These include proteins that regulate the transport of molecules across cell membranes, a model system for studying the triggers of immune response, an enzyme involved in cell division, and a genetic on-off switch in yeast that has potential for use in human gene therapy. These results could have an important impact because they serve as potential targets for the development of new drugs and therapies to fight cancer, neurological disorders, cardiovascular disease, endocrinological disorders, and a variety of genetic diseases.

**Successes:**

- Confirmed that green tea may be a significant factor contributing to the low rate of cancer incidents in Asian populations. Identified the biologically active compound in green tea.
- Developed a Botanical Center for Age-Related Diseases with the University of Alabama.

**Benefits:**

- Identification of biologically active ingredients in green tea could lead to the development of new cancer-targeting drugs.
- The Botanical Center will have impact on dietary supplement research and information delivery.

**State Assessment of Accomplishments:**

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

**Resources:**

Approximately \$386,000 and 4 FTE have been invested in this Goal. This is a best estimate and these are not presented as auditable numbers.

**Key Theme: Human Nutrition**

**FY '01 Focus: Scientific Basis for Optimal Health**

- a. *Description:* Purdue researchers are studying the effects of dietary fiber on cholesterol and bile acid metabolism and how this may alter the risks of heart disease and colon cancer. Some sources of dietary fiber are known to lower blood cholesterol levels, a risk factor for heart disease, while some sources reduce bile acid concentrations in the colon, a risk factor for colon cancer. The goal is to learn what sources of dietary fiber are effective and the mechanisms involved. Recent work has determined how psyllium impacts the reabsorption or excretion of bile acids in the small intestine. Work with psyllium has found that the reduction in blood cholesterol level appears to be as a result of a reduction in reabsorption of bile acids from the small intestine. This effect modifies cholesterol metabolism in several ways: 1) Reducing the amount of bile acids reabsorbed will allow more cholesterol to be used for bile acid synthesis. 2) Changes in the kind of bile acids has implications on the rate of cholesterol synthesis. 3) Reduced reabsorption will increase excretion of bile acids.
- b. *Impact:* Recommendations for increased consumption of sources of dietary fiber with the benefits suggested above can reduce the risk of chronic disease. This knowledge will help in making recommendations to the public to reduce risks for chronic disease.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

**Key Theme: Human Nutrition**

**FY '01 Focus: Modifying Food Intake Behavior**

- a. *Description:* A Purdue researcher noticed in a 1996 study that persons who drank alcohol or soda pop didn't adjust for the additional calories in their diets. The researcher gave a test food, a 450-calorie treat made mostly of sugar, to a group of test subjects and later substituted a beverage containing 450 calories. They noted the remaining daily dietary intake of subjects and monitored their weight.
- b. *Impact:* This research suggests that soft drink consumers may be unwittingly reaching for more calories, to the detriment of their health. When the test subjects ate the solid treat, they ate less of their usual diet, but when they consumed the same number of calories as a liquid, they did not adjust their dietary intake and thus gained weight.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

**Key Theme: Human Nutrition**

**FY '01 Focus: Scientific Basis for Optimal Health**

- a. *Description:* Cancer, strokes, and cardiovascular diseases are devastating diseases both personally and financially. Purdue researchers are investigating ways to reduce the risks of these diseases through diet modification and the functional foods. One nutritionist has begun to identify how nutrients such as vitamin D and a class of fats called sphingolipids regulate cell growth and death decisions at various stages of cancer progression and during a stroke. A food scientist is developing ways to increase the amounts of beneficial fats in eggs. The researcher determined the effects of chicken feed supplements on the amounts of conjugated linoleic acid (CLA) and docosahexaenoic acid (DHA) in eggs.
- b. *Impact:* Cardiovascular disease, cancer, and stroke are among the top causes of death in the U.S. Information from this study will lead to improved dietary recommendations for these nutrients that will 1) reduce the risks of developing cancer and 2) potentially greatly reduce the consequences of strokes. A Purdue researcher was able to produce eggs with higher amounts of CLA and DHA by modifying the feed of chickens. These fats help reduce the risk of cancer and cardiovascular disease.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

#### **Key Theme: Human Health Nutrition**

- a. *Description:* Inulin is a low-calorie sweetener that is safe for diabetics and is a soluble dietary fiber that promotes the healthy function of the intestine by stimulating bifidobacteria. Purdue researchers tested this commercially available additive for multiple benefits when used as a partial flour replacer in baked goods. The aim was to use this polymer to improve the nutritive value of cakes and investigate whether or not it may have an effect on the staling/firming process. They determined how much inulin can be incorporated (replacing an equivalent amount of the flour) into a standard yellow cake recipe and the effect of this addition on texture, water activity, and appearance.
- b. *Impact:* It appears that inulin may have a beneficial effect in reducing the staling/firming rate of cakes. This, in addition to its physiological effects makes it an especially valuable food additive. Use of such materials may help reduce the level of calories, especially more highly saturated fat calories, in the American diet as well as to incorporate bifidogenic materials into the diet.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

#### **Key Theme: Human Nutrition**

- a. *Description:* Beta-D glucan is a carbohydrate produced in significant amounts only in barley and oats. Oat bran has been shown to both lower cholesterol and moderate insulin demand in diabetics. A Purdue plant researcher has been trying to identify the gene(s) that encode the components of the beta-D-glucan synthase complex, and to investigate the potential for using the gene(s) to produce the nutrient in other, more widely used crops. Another Purdue researcher has found a way to synthesize

beta-D-glucan in vitro and determined the mechanisms for synthesis. The research has identified cellulose synthase-like genes that may be prime candidates for beta-glucan synthases.

- b. *Impact:* Glucan synthesis genes will be used to try to increase beta-D-glucan production in cereals such as rice and corn. This will facilitate the creation of new foods that lower blood cholesterol and reduce the risk of cardiovascular disease.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Human Health**

- a. *Description:* Purdue researchers are searching for ways to develop gene therapies that can alleviate suffering from the over 400 diseases caused by genetic deficiencies, such as diabetes mellitus and familial gout. The goal is to find a genetic switch that can be used to turn therapeutic genes on and off without requiring a hormone or antibiotic to induce the genes. They are conducting research on the use of a genetic on-off switch found in yeast.
- b. *Impact:* Purdue researchers found an on-off switch of interest (isopropylmalate). In the absence of an inducer, genes are inhibited by the regulator protein. When the inducer is added, the genes are turned on in a level proportional to the amount of inducer present. This system has been shown to work in cultured mouse cells. This switch could be very useful in gene therapy and other applications where tight control over gene expression is needed.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Human Health**

#### **FY '01 Focus: Scientific Basis for Optimal Health**

- a. *Description:* Nervous conduction, muscle contraction, and hormone release by endocrine cells are controlled by ion channels, a special class of proteins embedded in cell membranes. Neurotransmitters and hormones control nerve, endocrine and muscle function by regulating ion channels. A Purdue researcher is studying the biochemical reactions in cells that are triggered by neurotransmitters and hormones that alter ion channel function. The objective is to learn how ion channels are regulated and to better understand how nerves and muscles function under normal and diseased or injured states. Investigations focus on the enzymes involved in phosphorylation of sodium channels in the brain and potassium channels in endocrine cells.
- b. *Impact:* Purdue research has identified 1) nerve signals and specific enzymes, protein phosphatases, that alter the state of phosphorylation of sodium channels in the brain, and 2) a new enzyme, protein phosphatase 5, that is responsible for hormonal regulation of one form of potassium channel in endocrine cells. They have also shown that nervous regulation of a specific cardiac potassium channel requires a protein phosphatase. These studies alter the views of how ion channels are



regulated. The ion channel regulatory enzymes that have been identified may be new drug targets for controlling ion channels in the treatment of nervous, cardiovascular, or endocrinological disorders. This work reveals a potential path by which these environmental toxins may compromise nerve, muscle, or endocrine cell function.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Multistate

#### **GOAL 4: GREATER HARMONY BETWEEN AGRICULTURE AND THE ENVIRONMENT**

**Overview:** Production agriculture is dependent on the protection of our environmental resources, soil, water, and air. Purdue's focus for this research goal is to develop technologies, practices, and systems that sustain and enhance our natural resources while also addressing methods that enhance the productive capacity of the land. Research has been targeted towards management of natural resources at both the local and watershed scale to allow for improved water, soil and air quality.

The priority described above reflects the need to assist producers in meeting obligations associated with environmental quality standards such as those imposed under Total Maximum Daily Loads (TMDL). The general management principles associated with TMDLs are widely applicable and will produce an improved environmental quality. Purdue researchers have developed strategies to remove environmentally sensitive lands, typically found along streams and creeks, from agricultural production. They are testing innovative filter strip and windbreak designs that put in place valuable stands of trees that will produce income at a later date, while currently maintaining water quality. The researchers are studying the resulting changes in the patterns of wildlife including whitetail deer and bird populations in fragmented landscapes. The impact of urbanization on wildlife and stream ecology is also being assessed as part of the TMDL framework. Clearly, an effort that integrates environmental protection with the goal of enhancing biodiversity is warranted in order to achieve a sustainable watershed.

Purdue researchers are evaluating winter cover crops as a method to improve soil physical qualities and to limit runoff into streams and creeks thus improving water quality. Work conducted at Purdue's Water Quality Field Station (WQFS) is determining how crop rotations, fertilizer rates, and fertilizer sources (i.e., fertilizer versus manure) affect tile drainage water. This work has shown that when high rates of fertilizer are applied to continuous corn, water quality is threatened. Research results demonstrate that proper timing of fertilizer applications is critical to maintaining water quality and that this can be coupled with good yields

Concurrent work at the WQFS has shown that manure, while an acceptable source of N and P for plant growth, is also a significant source of *E. coli* and other microorganisms. This work suggests that *E. coli* are capable of surviving in soil for longer time periods than previously reported. The bacteria's survival pattern gives it the potential to leach to tile-lines and move with drainage water up to 6 months after application. Consequently, management of lands receiving manure must take into account both the nutrient and bacterial content of the biosolid to achieve optimal environmental conditions. Numerical and economics models coupled to multimedia presentation capture this information and facilitate public education.

As part of a watershed management strategy, Purdue researchers have shown that manure quality can be changed by manipulation of swine feed. Feed supplemented with synthetic amino acids, 10% soybean hull, or dried sugar, reduces manure nitrogen content by as much as 50%. Other research is assessing the potential to reduce P in manure with a similar diet manipulation approach. These reductions are significant because the modified manure can be applied to smaller land area and has a lower environmental impact. Also, with diet manipulation, ammonia content, a component of odor, can be reduced by as much as 64 % compared to a normal diet. The addition of fructooligosaccharide during diet manipulation improved the intestinal colonization of young swine by Bifidobacteria and reduced the *E. coli* content of the manure while enhancing weight gain to levels reported with antibiotic treated animals. With this approach it is possible to maintain animal productivity while improving environmental quality and reducing dependence on antibiotics as a feed supplement.

Like the situation found with TMDLs, the Food Quality Protection Act (FQPA) has the potential to alter farming practices. The FQPA may limit the use of many agricultural pesticides. Present and anticipated limitations on the use of pesticides have motivated work on the development of alternative control methods that will be critical to maintaining high quality products. Purdue researchers have been evaluating alternative strategies for pest control in vegetables, row crops and household and structural systems. One example where the new control options will be essential is management of the economically important western corn rootworm. Previously, crop rotation with soybeans was a preferred control approach. Recently, a variant form of the pest that has adapted to rotation makes this approach ineffective. A FQPA limit on the use of organophosphate pesticides has begun to create a demand for alternative approaches to control European red mites on apples. Purdue researchers are working with producers and homeowners on application techniques for old and new products that can be used in a manner that drastically reduces human and the environmental pesticide exposure and meets FQPA guidelines, for example, in the control of household and structural pests and the control of pests in public facilities such as schools.

#### **Successes:**

- Identified a process for valuing animal waste nutrients in the soil test process..

- Developed science-based setback guidelines that are being adopted and refined for use in the United States.

- Alternative technologies and diet manipulation have been shown to reduce odor emissions.

- Reducing the crude protein of pig diets and supplementing with synthetic amino acids and cellulose resulted in a significant reduction in the excretion of nitrogen in the manure and ammonia emission.

- Identified a new natural enemy against a major insect pest, the Colorado potato beetle.

- Quantified nutrient loading to tile drainage water and have shown that it is possible to achieve reduced loading with proper nutrient and manure management.

- Provided essential data for the state to facilitate compliance with the TMDL section of the Clean Water Act.

#### **Benefits:**

- Science-based setbacks calculated at Purdue have provided needed information to disputing parties, to state and national regulatory agencies and to the livestock industry.

- Filter strips improve water quality as well as provide economic benefits to the producer.

#### **State Assessment of Accomplishments:**

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

**Resources:**

Approximately \$2,008,000 and 18 FTE has been vested in this Goal. This is a best estimate and these are not presented as auditable numbers.

**Key Theme: Water Quality**

**FY '01 Focus: Water Quality**

- a. *Description:* Many watersheds across the Midwest are urbanizing at unprecedented rates. Roadways, parking lots, rooftops, and other impermeable surfaces associated with development have accelerated storm water runoff, causing major changes in the hydrology and water quality of the region. While these types of changes are thought to be detrimental, the specific relationship between various urbanization patterns and stream health and stability are not well understood. Purdue researchers are providing information on the characteristics of how the river systems are responding to these increased inputs of water. They are describing the physical habitat and characteristics of small streams that occur in a range of land use types, from agriculture to urban. These data are important because many of these streams are being considered as candidates for Total Maximum Daily Load (TMDL) development.
- b. *Impact:* Surveys have evaluated the response of stream organisms and their physical habitats to increased stream flow in urbanizing areas. Data has clarified the relationship between water input and the impact on aquatic invertebrates and algae. A strong correlation between the percentages of hard, impermeable, surfaces and the impact on the stream ecology are becoming apparent. A better understanding of the relationship between urbanization patterns and stream quality will contribute to sustainable watershed development. Related land-use issues such as farm land protection, urban planning, and infrastructure design can now be evaluated in light of their impact on water quality.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

**Key Theme: Riparian Management**

**FY '01 Focus: Water Quality**

- a. *Description:* Row crop and animal agriculture producers have been placed under increasing economic and environmental constraints. Optimal management decisions at the farm level to ensure farm sustainability must also ensure an equitable integration of the operation into the surrounding watershed. Purdue researchers have developed computer models and economic packages to assist agricultural producers in environmental enhancement. GRASIM, a computer model to evaluate land management practices in intensively grazed areas, has been widely used by producers and

researchers to define the most efficient use of natural resources. Researchers are investigating whether it is possible to take land near a stream out of livestock or agricultural production but still obtain income from the area. Modeling suggests that removing production adjacent to waterways is an efficient approach to improving water quality. However, producers are often reluctant to take this acreage out of production because of the loss of income.

In order to develop methods for the enhancing the adoption of filterstrip technology, researchers initiated a research and demonstration project in 1990 and have continued it for the last 10 years to determine if planting designs can be developed for filterstrips, windbreaks, and improved wildlife habitat while also providing a source of income. Tree and shrub species provided potential income when the branches were sold for ornamental use in the floriculture trade.

- b. *Impact:* The GRASIM model has provided a tool to estimate the impacts of land management practices. The model has also been useful in projecting impacts of recommendations in a proposed land use scenario. The model has found wide acceptance within the farming community and others interested in land management. Planting income-producing shrubs in the buffer strips improves the wildlife habitat and quality of the streams and provides income from this acreage. Initial numbers indicate income potential could exceed \$13,590 per hectare. The income-producing filterstrip concept was implemented on several Amish family farms in Indiana.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

## **Key Theme: Nutrient Management**

### **FY '01 Focus: Water Quality**

- a. *Description:* Water quality concerns including hypoxia have made nutrient loading of surface and ground water a key public environmental concern. Current recommendations for nitrogen fertilizer for intensive production agriculture frequently do not result in the application of the optimum rate. The efficiency of N fertilizer can be improved with a better understanding of the N balance of a crop system that includes the accurate assessment of the native soil N supply. Purdue researchers have established a Water Quality Field Station where fertilizer N loss to surface water is measured on a daily basis. They are evaluating different N management systems, including rotations, fertilizer rates, and fertilizer sources (inorganic versus manure) for their impact on surface water quality. Highest fertilizer rates applied to continuous corn appear to be the greatest relative non-point source of nitrates to tile drainage water. More recently they have expanded this work to evaluate the contribution of N and bacteria from manure to surface water. Watershed management under a Total Daily Maximum Load (TMDL) approach is based on the concept that once a contaminant enters a water system, degradation, sorption, and dilution will allow the system to assimilate (remove) the introduced contaminate materials. At present, consideration is not given to the potential for biological activity from the pollutant that may reverse this pattern. This is a significant oversight in the TMDL plan given that the pollutant is a living organism growing and increasing in numbers.

- b. *Impact:* Research has shown that reduction in nitrate loading of tile drainage water can be achieved by implementing better N management practices in continuous corn and corn/soybean production systems. These data are essential in order to develop a basis for compliance with the TMDL section of the 303(d) portion of the Clean Water Act. Research data suggests that assumptions of short lifetimes for *E. coli* in the environment are invalid. A lack of understanding about the behavior of *E. coli* in the environment makes it difficult to develop acceptable TMDLs or to understand the fate of the bacteria. These studies suggest that current land application practices may have unknowingly lessened a number of the stress factors that reduce the number of bacteria following a soil application.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Air Quality**

- a. *Description:* Livestock and poultry producers have established large concentrated facilities to compete in today's market. Public responses to odor emissions and stricter regulations concerning gas emissions have increased the need for knowledge about quantities of odor and gas emissions from livestock facilities. A balance between the needs of the producers and adjacent neighbors must be established. Air pollutants in livestock buildings may represent a risk to the health of livestock and of workers. These air pollutants may also represent a risk of pollution to the wider environment. A great need exists for standardization of sampling and measurement of air pollutant emissions from livestock housing. Purdue researchers are measuring the effects of mitigation techniques using different procedures without common protocol. Quantifying gas emissions from livestock buildings is a complex process. The dynamic nature of ammonia and dust concentrations in selecting representative measurement points and the lengths of sampling periods is of critical importance. The Purdue Agricultural Air Quality Laboratory (PAAQL) has conducted emission measurements at livestock facilities since 1995, including a major field test of indoor air quality and emissions of ammonia, hydrogen sulfide and odor at large swine facilities. A total of 34 and 28 building-months of gas emission data were collected. These data are the first to fully quantify the spatial relationship between odor (gases and particulates) and set back distance.
- b. *Impact:* Odor and gas emission studies at commercial swine facilities have provided needed measurement technology and information about air pollution source strength. Data from these field studies are being utilized by individuals and organizations throughout the United States to reevaluate the rules and regulations concerning building location and set back distances.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Animal Waste Management**

- a. *Description:* A major threat to the growth and sustainability of the pork industry in Indiana and the U.S. is potential water quality problems and manure odors from confined feeding operations. In addition, the health and well-being of the confined swine are at stake if feed additive antibiotics are not used. Stricter laws throughout the country have put considerable pressure on the pork industry to find acceptable alternative methods that reduce manure and odor and limit the use of antibiotics. Purdue researchers are investigating the effects of diet manipulation on manure excretion nutrients, odors, and animal health and developing management techniques to significantly reduce nutrient excretions and odors from swine operations. In studies with pigs, they have reduced the crude protein content of the diet by supplementing with synthetic amino acids and 10% soybean hulls or dried sugar beet pulp. This regime has reduced the excretion of total nitrogen in fresh manure from 42 to 50%. In addition, with the lower protein and synthetic amino acids alone (11% crude protein), nitrogen excretion was reduced by 38% compared to a standard diet (15% crude protein). Ammonia emissions were reduced 39% and 64% in stored manure with low protein and soy hulls or beet pulp diets, respectively, compared to a standard diet. In group feeding nursery trials, the addition of 5% fructooligosaccharide in nursery pig diets improved feed efficiency with similar weight gains in pigs compared to those fed an antibiotic control diet. Fructooligosaccharide increased colonization of Bifidobacteria and reduced *E. coli* in the intestinal system of the weanling pig. These specific oligosaccharides added to weanling diets may help sustain pig health during the transition of the pig from milk diets to dry feed and other normal stresses of weaning.
- b. *Impact:* Balancing the available amino acid profile and adding small amounts of specific fiber to pig diet have dramatically reduce nitrogen excretion and odors. This will reduce the amount of land needed for manure application, reduce the threat to water quality and reduce the offensiveness of odors. This will enhance the potential for compatibility of pork production with the rural environment. An alternative to antibiotics in pig diets is likely to become a major need because regulators are screening existing approved antibiotics and several have been removed for use in animal diets. Non-antibiotic alternatives such as oligosaccharides have promise for controlling the microbial ecology of the intestinal system of the pig and reducing the threat of pathogenic diseases. Diet manipulation has promise as a practical and effective solution to significantly reducing odors, as well as nutrient overload in pork operations.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

**Key Theme: Integrated Pest Management**

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

- a. *Description:* High maintenance turf, such as golf course greens, tees, and fairways, require repeated fungicide applications to limit damage caused by a variety of fungal diseases. Take-all patch, caused by *Gaeumannomyces graminis* f. sp. *avenae* (Gga), is one such disease that is

especially troublesome on alkaline, high sand content, creeping bentgrass greens constructed to USGA specifications. Purdue researchers designed field experiments to investigate the influence of construction-phase root zone acidifying treatments, fungicide application, and nitrogen applications on take-all patch development. Initially take-all patch symptom expression was significantly reduced by all treatments. However, in the following year, root zone pH returned to that of the initial root zone mix (approximately 7.5), and that the pH factor did not affect take-all patch development 2 years after the aluminum sulfate application. The only treatments that significantly suppressed disease development involved fungicide applications in April and May. There also appeared to be no influence of pH on fungicide performance.

- b. *Impact:* Altering the pH in the top 1 or 2 inches of substrate, (prior to establishment of creeping bentgrass turf) to levels that do not favor pathogen growth and take-all patch development, may significantly lessen these pathogens in the first-year turf. Although the pH effect is not expected to last, early suppression of disease may contribute to improved performance of other control options. This approach could reduce the need for pesticide inputs.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Biodiversity**

- a. *Description:* All ecosystems require microorganisms to perform numerous essential tasks from cycling organic nutrients to degrading pollutants. Microorganisms are critical to overall ecosystem structure and function, yet very little is known about the composition and dynamics of this component of terrestrial ecosystems. Purdue researchers worked on genetic fingerprinting methods to compare the structure of microbial communities present in agricultural soils and differentiated microbial communities in the rhizosphere of corn and soybean under varied agronomic treatments. More recently they used this approach to screen soil samples for genes that reveal the presence of enzyme produced by a pollution-degrading bacteria. Presence of the enzyme indicates the presence of bacteria capable of cleaning. Information on the occurrence and quantification of the bacteria in the system will facilitate monitoring to determine the progress on removal of toxins from soil.
- b. *Impact:* This study furthers our understanding of a basic mechanism contributing to the immense diversity in biological processes for maintaining and improving soil and environmental quality. Research has shown the applicability of a genetic fingerprinting method to determine the impact of various agronomic management schemes on the soil microbial community.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **GOAL 5. ENHANCED ECONOMIC OPPORTUNITIES AND QUALITY OF LIFE FOR**

## AMERICANS

**Overview:** The timely transfer of information and technology is critical to ensuring and maintaining strong families and business entrepreneurship in Indiana communities. Purdue researchers have established information resources that will enhance 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. Availability of resources, services, opportunities, and information plays a key role in the potential for people to attain a desired quality of life. Purdue researchers have developed information resources to establish and maintain business enterprises by enhancing the human capacity at the local level. The key to improved quality of life is enhancing the human capacity through educating, developing leadership and making information resource available.

Purdue researchers have worked towards better understanding of business resources and how they interact with the family structure to assist the citizens of Indiana in balancing their family and work lives. Recent surveys conducted by Purdue researchers have evaluated the conflict that exists when a family member is also the owner of a family business. Some 13 million U.S. households have at least one individual who is the owner-manager of a family business. Developing an understanding of the effects of the business on the family and vice versa is critical for understanding all of the factors that affect the success of the entrepreneurial operation and, in the long run, the stability of the community. Purdue work has focused on how the family affects the business operations, and this is a departure from most other studies. From this work, it is clear that family support and responsiveness are key factors in the success of business and its survival over time. These survey data are now used to underpin a series of seminars and workshops that are being offered to help the family businesses become successful. The interactive nature of the relationship between the family business and the family function has been ignored for too long.

Purdue researchers have used surveys to assess the impact of financial concerns upon family well-being and stability. These data are key in developing a clear understanding of how financial concerns control the levels of family stress and the subsequent consequences of this stress including divorce and poor job performance. They show that debt will have negative effects on job performance and that debt level will affect job selection for the recent college graduate. They show that a careful consideration of the balance among debts, methods to reconstruct debt and family function are needed to avoid undue hardship and to sustain the quality of life.

Entrepreneurs with a unique idea can benefit from science-based information on evaluating options for economic development. Locally based enterprises are important to the economic development of a community. The economic viability of community, family, and individual depends on a complex, interwoven, and interdependent situation. Purdue researchers are developing and evaluating novel methods that businesses can employ to use locally available resources such as wood residues and semi-processed woody materials to develop profitable cottage industries. The proposed cottage industries could produce such products as chairs, desks, and tables constructed from wood residues. This program is especially well suited for communities situated in forested areas because it makes use of materials that have high local availability.

The researchers have also encouraged the development of the recreational industry by working with local communities to highlight and detail the unique characteristics of historic site-based programs that combine cultural, recreational, and tourism. The impact on small communities can be tremendous in terms of new financial resources. In this way, the quality of life of the local communities is improved, as is the life of the visitor. These programs are coupled to efforts using geographic information systems (GIS) as a powerful method to catalog and inventory local resources. By applying GIS to real-world situations and using GIS



models that run on the internet, small towns across Indiana and the U.S. have access to computerized urban planning tools now used only by large cities. The impact is significant. Small to medium-sized communities that were unable to achieve their desired level of planning now have the tools and ability to improve streets, roads, and placement of railways and water lines. All of these improvements significantly enhance communities' quality of life.

**Successes:**

Designed and implemented a science-based pest management strategy for schools

Purdue developed the science-based Expanded Food and Nutrition Education Program (EFNEP) and uses Family Nutrition Advisors (trained paraprofessionals) to teach food and nutrition topics to limited resource families in their homes or community sites in 23 Indiana counties.

Analysis of tourism and recreational data focused primarily on historical and cultural site destinations provides site management key information for capitalizing on marketing and services. Leaders in local communities have gained new knowledge through regional workshops and community forums.

**Benefits:**

The school pest management program resulted in effective pest control, major cost reduction, and significantly less exposure of students to pesticides.

Utilizing Purdue University's Land Use Team, Ripley County's Comprehensive Plan was modified. The plan is targeted to improve the quality of life and revise zoning ordinances to plan for development. Ninety percent of EFNEP participants improved their intake of nutritious foods, 88 percent improved other nutrition practices and 82 percent improved their food resource management skills, saving from \$50-\$100 per month in food costs.

More than 500 elected and appointed officials attended seven workshops for county plan commissions. The work by the Land Use Team has led to more-informed public decision-making at the local level regarding land use. Several communities have revised local ordinances and improved their decision-making processes.

The tourism study benefited communities in designing tourist attractions and activities.

**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. We have clearly demonstrated approaches to be used by families and communities to improve in terms of job and family stability and job satisfaction. We are providing producers with alternatives in terms of debt reduction, debt restructuring, community help, planning and zoning and reduction in family stress.

**Resources:**

Approximately \$292,000 and 3 FTE have been invested in this Goal. This is a best estimate and these are not presented as auditable numbers.

**5.A. Improved Quality of Life**

**Key Theme: Children, Youth, and Families at Risk**

- a. *Description:* Pests in public schools are considered an increasing problem, primarily due to their direct and indirect human health and environmental impact. Pests not only disrupt the classroom, but they may also spread diseases and have recently been implicated in cases of childhood asthma. Pesticides, traditionally relied upon to control pests in schools, have themselves been implicated in student health problems. Public outcry about environmental contamination, FQPA, and children's safety has recently mandated that pests be controlled in a more efficient and responsible manner. Integrated pest management (IPM) is the proven solution. Implementing IPM, however, is a major challenge in Indiana, where the nearly 300 school corporations manage over 1,943 school buildings. Providing the technical training and support, required by schools in implementing IPM is the first step in fostering state-wide adoption. Purdue researchers have conducted surveys to assess the dimensions of the issue and the needs and capacities of Indiana's school buildings.
- b. *Impact:* A pilot implementation at a public school corporation, based on research, has shown a yearly reduction in pest management costs from \$34,000 to \$19,400. More important, the effectiveness of the pest suppression program, as measured by number of pest complaints, decreased by 80% during the pilot program. This was accomplished while reducing the amount of pesticides applied in the school building by 92%. Purdue researchers have worked closely with Indiana legislators in developing proposed legislation including testifying before a senate subcommittee on IPM in school matters. State legislators in favor of an IPM program have agreed IPM adoption should precede official legislative mandates. How to facilitate this adoption is of considerable debate. Purdue researchers have worked closely with the Pesticide Review Board and the Indiana School Boards Association in proposing, drafting and adopting a model policy for use by all public schools in Indiana. Through a series of 8 independent day-long workshops, staff have trained school administrators, school facility managers, custodians, kitchen staff, and landscapers in the mechanics of IPM. They have also given Pest Control Professionals training in the art and science of IPM in schools.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

## **Key Theme: Tourism**

- a. *Description:* Historical and cultural site participation is one of the fastest growing areas of domestic and global tourism and recreation. The cultural/heritage tourism emphasis is grounded in research findings showing that historical sites, museums, and art events attract millions of visitors and travelers per year. In 1999, the National Park Service reported over 96 million recreational visits to any type of cultural resource, including historical and archeological places (63% of National Park areas administered). Improving knowledge about this incredibly large number of users influences how both public and private sector organizations manage and plan. Purdue researchers examined the nature of historical site-based participation and connected this with involvement in other leisure activities such as attending live art performances. Their second step used this information to improve the behavioral conceptualization of leisure and tourism, particularly as it relates to culture and heritage. The unique characteristics of historic site-based participation that combines cultural, recreational, and tourism elements clearly suggest a need for new management

strategies. Land management agencies, cultural and tourist organizations as and communities will need to work more closely to diversify choices offered at their sites for traditional and emerging recreation and culture styles.

- b. *Impact:* Tourism is a \$5.5 billion economic activity in Indiana. Cultural and heritage activities with historic sites as a major component draw more visitors than most other areas of activity. This is a key finding of their research. The models that have been developed define the structure of visitor participation and allow agencies to better understand current users, consider future levels of use, and improve marketing activities linked to economic development.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

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

### **Key Theme: Family Resource Management**

- a. *Description:* In the late 1990s, Purdue researchers identified and analyzed financial concerns of families and their effect on economic well-being and on the family members' productivity at work and at school. They conducted surveys of families and consumers via personal interviews and analyzed documented effects on reported financial difficulty, quality of life, and productivity. They also analyzed responses from survey participants to provide support for informed decisions. The researchers found that loan consolidation undertaken by survey participants increased financial costs, stress, and debt difficulties rather than reducing them. A conservative estimate suggests that 15% of employees are anxious over financial concerns which reduces their productivity and that about 30% of college students are anxious enough that financial concerns affect their studies and career prospects negatively. The researchers determined that financial counseling is needed more than education to assist employees in maintaining employment and productivity. They also found that the greatest cause of monthly financial deficit is housing expenditures and that non-mortgage expenditures have increased in dollar cost and portion of total housing cost for the last 15 years.
- b. *Impact:* Consumers now have information about total housing expenditures to assist them in making housing decisions that will not result in monthly deficits and financial difficulties. The disadvantages of loan consolidation have been identified. The need for programs to assist college students with their financial concerns, helping them concentrate on studies and avoiding debt has been underscored. The emerging profession of financial counseling can use this information to become more effective at assisting clients in improving their economic well-being by informing them of all types of housing and transportation expenditures, and of probable changes in expenditures after retirement. They can assist them in divorce decisions and in combining work and family responsibilities.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

### **Key Theme: Family Resource Management**

- a. *Description:* Many women are discovering that they face different challenges than their mothers did when it comes to preparing for their later years. Women must think in terms of providing for themselves in their later years. They typically live 6 years longer than men do. Seventy percent of baby-boom women are expected to outlive their husbands. Many can expect to be widows for 15 to 20 years. Nearly a third of single women over age 75 are living in poverty, having less than \$700 a month to live on. A recent survey conducted by Purdue researchers revealed that only 40% of women believe that saving and investing are the most effective strategy for wealth building. Purdue researchers used this information to develop the Women's Financial Information Program which is targeted to increasing participants' financial knowledge and confidence in their financial decision-making skills.
- b. *Impact:* Purdue researchers conducted pre-and post-assessments to learn what participants had done as a result of participating in the Women's Financial Information Program. Sixty-six percent of the participants reported they set goals during the program. Thirty-six percent said they began or increased regular savings. Fifty-three percent said they discussed financial matters with other family members. Thirty-nine percent said they determined retirement income needs and how to meet them, while 40% indicated they planned to do that in the future. Before the program, 53% agreed or strongly agreed that they were confident about managing money. After the program, 87% agreed or strongly agreed that they were confident about managing money. Before the program, 44% said they agreed or strongly agreed that they had the knowledge, skill, and ability to affect their financial position in a positive manner. After the program, 92% agreed or strongly agreed that they had the knowledge, skill, and ability to affect their financial position in a positive manner.
- c. *Source of Federal Funds:* Hatch
- d. *Scope of Impact:* Multistate

## **B. STAKEHOLDER INPUT PROCESS**

Purdue University faculty and staff engage stakeholders on a daily basis through research, extension, and teaching activities, which occur both within the university setting and out in the state. Over one-third of the faculty in Agriculture at Purdue have a joint research/extension appointment. These faculty have extensive interaction with stakeholders through scheduled meetings, on farm research, problem solving consultations, etc. Staff participate in a wide variety of state and local events including conferences, commodity marketing and agricultural interest group meetings.

Purdue Agriculture has seven Ag Centers strategically located across the state. These Centers serve as interaction points with stakeholders to gain ideas and interact on-site regarding agriculture related issues, needs, and developments. Regular field days, consultations and tours are held at all Centers. Purdue based faculty participants in those activities.

Indiana has a highly diverse group of organizations that involve producers and citizens with interests in agriculture and the environment, production, processing and marketing spanning a broad range of animal and plant species. There are over 20 state organizations including grower/producer associations, commodity associations, state authorized boards, study groups, cooperatives, etc. Purdue Agriculture has specifically named representation/liaison with 14 organizations. This provides access to a highly diverse group of citizens with a broad range of views and interests. These groups/organizations provide a very rich source of information on topics and concerns of people from across the state.

Several information gathering meetings are convened by Purdue Agriculture. These have very different participants identified from different population pools with varied objectives. Several of these groups and meetings are described in the following paragraphs.

### **Council for Agricultural Research, Extension, and Teaching**

The Council for Agricultural Research, Extension, and Teaching (CARET) hold regional meetings throughout the state in both the Spring and Fall. These meetings are attended by representatives from Purdue Agriculture who update CARET members on new initiatives and programs. Questionnaires were used at the Fall 1999 meetings to provide an assessment of research and educational priorities. In addition, an annual meeting for all CARET members is hosted by the School on the Purdue campus. At the annual meeting in November 1999, 4 concurrent sessions explored a range of topics including New Enterprise Development, GMOs and International Trade, Lifelong Learning, and Economic Development and Land Use. Table discussions at each session were focused on questions developed by Purdue staff. Participant ideas were recorded for each session and compiled into a report.

The CARET organization exists at many levels including county, region/area, and state. At the county level, the committee members are identified by current CARET members, county staff and the County Extension Board. County committees elect representatives to the area committee. Area committees elect state leadership. CARET membership spans a wide range of occupations and interests, including school teachers, livestock and crop farmers, and local business owners.

### **Purdue Agricultural Centers Advisory Teams**

The Purdue Agricultural Centers (PAC), 8 field research centers located throughout the state, have 5 advisory teams which meet annually. A facilitator was used for a meeting to engage the teams in needs identification and prioritization. Both focused and open-ended discussion sessions were used to encourage participation by those in attendance. Approximately 75 people attended the meeting.

Advisory team members were identified by the PAC Director and PAC Superintendents based on recommendations by local extension educators and PAC staff. These members represented producers and related clientele in the areas served by the PACs. Facilitated discussion and questionnaires were used to collect stakeholder input on possible research priorities.

### **Agricultural Economic Outlook Sessions**

Agricultural Economic Outlook presentations were given at 42 locations throughout the state by Purdue Agricultural Economics faculty. Following a current forecast presentation for agricultural businesses and producers, attendees were asked to complete evaluation forms which included a question on the prioritization of state research and extension issues. These meetings were open to the public. Announcements of the Outlook meetings were advertised through local media to generate attendance. Over 2,000 people attended the Outlook meetings.

### **Deans Advisory Council**

The Dean's Advisory Council (DAC) meets twice a year. The DAC is made up of representatives from primary and secondary education, producers, farm input industries, banking, agriculture and community associations, the legislature, environmental organizations, and others. Members are chosen by the Dean with input from the Department Heads. This is a highly engaged group whose primary purpose is to provide a broad client, stakeholder input. The Council was asked to synthesize information from the CARET, PAC, and Economic Outlook meetings, and think about long-range planning and the future of Agriculture in Indiana. The group was asked to define a shared vision and identify action steps and roles for the School. The defined vision and action steps were developed into a report and distributed.

### **Consideration of Collected Input**

Reports were generated from all meetings and conferences where stakeholder input was solicited. These reports were distributed to Associate Deans of Research and relevant Departments for use in strategic planning of research and education programs.

Two of the School's major initiatives which impacted Agricultural Research Programs were developed in response to themes that emerged from the stakeholder meetings. Areas of great concern for stakeholders included the development of value-added agricultural products and the development of genomics and biotechnology in support of agriculturally important species. The growing need for research on value-added agriculture is being addressed through the hiring of a cluster of faculty to focus on functional genomics and biotechnology to improve the value of grain and horticultural crops. In response to the desire for advances in biotechnology and the need for public investment in genomics, Purdue University has made genomics and

biotechnology one of three major University initiatives and proposed a \$4.5 Million initiative in this year's state legislative budget request.

### **C. PROGRAM REVIEW PROCESS**

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



#### **D. EVALUATION OF SUCCESS OF MULTI AND JOINT ACTIVITIES**

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

Animal waste management is a problem identified by stakeholders, policy makers, and the public. Indiana has joined in a consortium with other states to investigate approaches to modify animal waste output and identify improved methods to deal with waste. Researchers have used results of studies in working with various agencies in developing rules and regulations describing TMDL's. Research findings have enabled them to design and modify systems to help producers meet regulations. Science and education have influenced production practices and rule making and provided a common base for dialogue and negotiations among producers and regulators. As a result, improved regulations are evolving.

Return on investment for beef producers is an economic issue in the North Central region. A five-state consortium was formed and has been funded. The consortium includes representatives from producers, associations, state departments of agriculture, and universities. The consortium has held several planning meetings. Production efficiencies and marketing approaches are the primary emphasis. A major initiative under way is the marketing of a superior cut of meat through genetics, management, and nutrition. Label identity has been developed for "quality beef" to promote a value-added return. This project addresses an issue identified by livestock producers.

Bees are essential pollinators required for the production of a number of crops. In recent years the appearance of several diseases and parasites has created a major problem in bee health and survival, and thus effected crop pollination and production. Indiana was the lead state in developing a multistate project to investigate bee health and survival. Meetings have been held, and topics for research and education were prioritized. Apiculture expertise is very limited in the region, and this multistate program is ideally suited to pool knowledge and resources. Beekeepers identified apiculture as an under served area having problems that could benefit from research. In fact, they approached the legislators in search of resources to investigate the problems. In response to this need identified by an "under-served population" Purdue has employed a scientist to address the problem. Information developed by this scientist will benefit both backyard hobbyist and commercial beekeepers.

The identification of a new pest in a major commodity is a critical issue to stakeholders/producers. Soybean aphid was identified in the region in late summer 2000. Purdue provided the leadership in fall 2000 for initiating and developing a multistate meeting to assess the problem and plan a program. Over 40 scientists from 10 states participated in prioritizing needs and developed working groups to investigate critical issues for this invasive species. Research was planned and prioritized and proposals have been written. Multistate, multidiscipline, and multifunction funding has been obtained from several sources. A multistate publication was produced and distributed. Information has been distributed via many channels, including extension and Soybean Association Growers meetings. This is an example of a program meeting an invasive species issue of potential strategic importance in crop production.

Indiana is the lead state in managing the two-state (Indiana, Illinois) Sea Grant Program. Lakes and streams are an environmental resource and provide recreation and food. Pollutants and invasive species such as the zebra

mussel affect the value and productivity of that resource. Joint investigations by Indiana and Illinois led to some mitigating strategies and numerous multimedia information pieces. Users of waterways, whether for business or pleasure, were provided information on practices that would aid in mitigating the problem.

European Corn Borer (ECB) is an economic pest in corn production. Bt has been introduced into the corn plant and is effective in controlling ECB. Use of this technology raises several issues, including cost/benefits to producer, development of resistance to Bt, etc. Entomologists, economists, and modelers collaborating in a multistate project developed a model to project cost/benefit. One outcome has been that reported planting of Bt corn is declining. There may be causes beyond the cost/benefit affecting the decline. The issue of resistance development by ECB to Bt was posed by scientists and regulators. The multistate, multidiscipline team developed scenarios based on scientific data and modeling to project the potential for the development of ECB resistance to Bt. The outcome of this project was that the regulatory agency relied on this information to craft a regulatory program that is projected to minimize the potential for Bt resistance development in ECB.

The report "Reducing Negative Inputs from Agriculture" under Section F is also an example of a multi/joint activity.

## **F. INTEGRATED RESEARCH AND EXTENSION ACTIVITIES**

### **Greater Harmony Between Agriculture and the Environment**

Hypoxia has been identified in a significant area in the Gulf of Mexico. Assessments have projected that a potential cause of this situation involves agricultural practices in the Midwest. The study identified the relative costs and cost-effectiveness of different measures for reducing nitrogen loads to achieve benefits within the Mississippi River Basin. The scenarios considered in assessing options included fertilizer restrictions, land use, wetland-restoration, buffers, etc.

Purdue faculty undertook follow-up work on the assessment of hypoxia in the Gulf of Mexico. This involved analysis for policy makers on costs and likely impacts from efforts to reduce nitrogen flows to the Gulf of Mexico. Current activity includes the design of policies that might be applied to reduce nitrogen losses. Work was initiated on identify and assess potential options to minimize the impact in the gulf, including green payments and other environmental programs that might be part of the coming farm bill legislation.

The formation of policies by responsible parties to try to ameliorate nitrogen flows to the Gulf of Mexico has used the economic analysis in the economic assessment report and subsequent analysis of program costs and impacts.

### **Greater Harmony Between Agriculture and the Environment**

Many Indiana soils are wet. About 45% of the soils are wet enough that crops respond to artificial drainage. The most productive soils of the state are naturally wet, and many have been tile drained. Also, wetlands need to be preserved to recharge aquifers, purify water, provide wildlife habitat, and offer recreation. To understand how soils function as wetlands and how they respond to different kinds of drainage systems, we need to know more about how the water table fluctuates in soils, how water moves through soil profiles and soil landscapes, how saturated soils cause chemical reduction in soils, and how reduction processes are recorded in soil morphology.

One of the study areas is in the Jasper Pulaski Fish and Wildlife Area, where well drained sand dunes rise above a wet sand plain. Measurements included table depths, oxidation-reduction potential, and soil temperature at 15 sites that represent the range in soil hydrology. Surveys were conducted using ground-penetrating radar and information was extrapolated from these 15 sites to entire landscapes. This study identified the annual progression of water table depth (WT) under the low-lying sand plain and the dunes that rise above it. In September-November, the WT is at its annual low, is flat, and thus is much deeper under the dune than under the sand plain. In December-February, the soil begins to wet up. It takes more water to saturate the soil under the dune than under the sand plain because of the difference in depth to the WT, so the WT rises faster under the sand plain. Because of this gradient, subsurface water flows from sand plain to dune. In March-May, the WT under the sand plain rises to the soil surface, but not higher because of surface runoff. Under the dune, however, it continues to rise, again becomes flat, and mounds under the dune. In June-August, tree roots lower the WT under the sand plain. Under the dune, however, the WT is below rooting depth so plant water uptake lowers the WT very little. Subsurface flow is from dune to sand plain.

The results of the study increased the understanding of processes in natural wetlands and also help predict how potential agricultural contaminants will behave in wet soils. These research sites are being used to train wetland investigators who will identify wetlands in all part of the U.S.

The information from this project is also used by land planners. Another outgrowth has been the development of a manual for broad use in education, for example, 4-H, classroom, and adult education outreach. Students can consider and project the impact of different scenarios, such as preservation of a wetland, draining for ag production, draining for housing development, etc.

### **Animal Disease, Health and Well-Being**

Researchers discovered that conjugated linoleic acid (CLA) can alter the deposition and usage of other fatty acids in layers, chicks, pigs and rats. Rats were used to test how CLA may work in humans consuming CLA enriched animal products. The addition of 0.5% CLA directly to a control diet containing 15% pork fat decreased feed intake and growth of rats when compared to those fed either the control diet or a diet containing 15% of CLA-enriched port fat from pigs that had received a diet containing 0.5% CLA. When fed to rats, both CLA diets (direct CLA addition or via CLA-enriched pork fat) decreased the protein content of very low-density lipoproteins (VLDL) particles. However, the direct CLA addition also increased the triglyceride content of VLDL particles. CLA was shown to alter the composition of VLDL particles, the primary carriers of triglycerides. This is of significant importance, since CLDL particles are now being implicated to play a much bigger role that expected in coronary heart disease. This study clearly illustrates that CLA affects VLDL protein and triglyceridecontent. This data from rat studies raises the question about the potential beneficial effects of dietary CLA in humans.

This information is made available to the food industry. There is the potential to have an impact on how food is processed and prepared, thus impacting a primary health issue – coronary heart disease.

### **Animal Disease, Health and Well-Being**

The public perceives milk to be a wholesome and healthful commodity. As consumers become increasingly aware of issues related to food quality and food safety, the dairy industry is stepping up its efforts to provide milk of even greater quality to maintain the public's confidence. Mastitis (inflammation of the udder) remains the most costly disease of dairy cattle, and it costs the Indiana dairy industry upwards of \$27 million per year. The problem was addressed in several ways. Detection methods were evaluated for the identification of short and long mastitis episode duration. A new approach to detection, infrared imaging, showed some potential. The detection studies also identified cows that had not been previously shown to have clinical infections. Thus there might be some promise for an early warning. It was also found that short duration episodes are apparently less regulated by genetics than the chronic, long duration episodes.

Milk quality workshops were planned and delivered in cooperation with the Indiana Board of Animal Health, Indiana milking equipment dealers, and milk cooperatives. Dairy farm employees, managers, and dairy farm professionals received training. A distance learning module on production was developed. The first Indiana Milk Quality Conference was held April 26-27, 2000, Anderson, IN, in cooperation with Creamery License Division, Indiana Board of Animal Health, and state dairy cooperative.

Improvement of milk quality through reduction of mastitis provides consumers with a more wholesome and safer dairy products; benefits dairy producers through increase milk quality incentives, lower costs of veterinary care, less discarded milk, and it also enhances the well being and longevity of cows. Since initiation of milk quality programs in 1997, somatic cell counts have dropped 32,000 per cow, which results in an additional \$2100 of income on an average sized dairy farm.

### **Animal Disease, Health and Well-Being**

There is continued public pressure to stop using growth promotant type feed grade antibiotics in livestock rations to reduce the potential for development of antibiotic resistant organisms. Faculty explored the potential of alternatives to antibiotic use. Conjugated linoleic acid (CLA) has the potential to stimulate an animal's natural immune system. This may serve to enhance a pig's natural ability to fight off typical disease challenges observed in production and may be an alternative to feed grade antibiotics.

Faculty evaluated CLA in nursery and early grow-finish diets as an alternative to feed grade antibiotics. Feed grade antibiotics in rations did significantly improve pig growth rate and feed efficiency. Feeding antibiotics may not be an economical alternative when considering cost per lb. of gain. CLA at 0.6% in diet fed weaning pigs for 9 weeks did not improve growth performance. CLA did improve the pig's natural response to a bacterial disease, *Mycoplasma hyopneumoniae*.

The use of CLA in combination with a sound vaccination program to enhance the pig's natural immunity and resistance to disease challenges may be a viable alternative to using feed grade antibiotics. Economics will likely be the deciding factor as the pork producer considers the bottom line. Information was disseminated to swine producers and feed formulators via newsletter, Swine Day, etc.

### **Enhanced Economic Opportunity and Quality of Life for Americans**

Insects are often unwanted guests in homes and other buildings. Although most insects entering buildings are just annoying, some do damage or cause health problems.

Studies have focused on the biology, behavior, and control of German cockroaches, the most common insect pest in structures inhabited by people. Pesticides are frequently used to control German cockroaches. Pesticide use in a building also represents a risk. Furthermore, roaches can become resistant to pesticides. The study identified roach food preferences, movement patterns, and toxicity/effectiveness of pesticides. An attractive food base (a bait) with an incorporated pesticide, in a "designed container," and strategically placed provided control in a safe and environmentally benign manner.

Hundreds of pest control operators and home inspectors have been trained this year to identify damaging insects and how to conduct insecticide treatments. A primary outreach for this information is the Annual Purdue Pest Control Conference attended by over 800 professionals who provide service to a broad customer base, including homes, hospitals, factories, and schools.



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

Institute	Purdue University
State	Indiana

Check One:		<b>Multistate Extension Activities</b>
	X	<b>Integrated Activities (Hatch Act Funds)</b>
		<b>Integrated Activities (Smith-Lever Act Funds)</b>

**Actual Expenditures**

Name of Planned Program/Activity	FY2000	FY2001	FY2002	FY2003	FY2004
Water Harmony Between Agriculture and Environment	10,750				
Water Harmony Between Agriculture and Environment	27,473				
Animal Disease, Health and Well-Being	10,750				
Animal Disease, Health and Well-Being	1,314				
Animal Disease, Health and Well-Being	8,361				
Enhanced Economic Opportunity and Quality of Life for Americans	1,075				
<b>Total</b>	<b>59,723</b>				

\_\_\_\_\_  
 Director

\_\_\_\_\_  
 Date

