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: Maintaining a sustainable crop, livestock, and natural resource system is essential for the Indiana economy. For 2002 (the most recent year available), cash receipts for Indiana agriculture were $4.8 billion with 68% from crop sales and 32% from livestock sales. Indiana ranked ninth nationally in crop receipts in 2002. The 63,000 farms in Indiana represent 3% of all U.S. farms. In 2002, Indiana agricultural exports were estimated at $1.7 billion, about 3% of total U.S. agricultural exports. Despite being a relatively small state with only 1.6% of total U.S. cropland, in 2002, Indiana ranked second in processing tomato and ice cream production, fourth in peppermint and soybean production, and fifth in corn, egg, and hog production. The challenge for Indiana farmers is to adopt and manage agricultural production practices that are environmentally sound, yet allow them to remain competitive in a dynamic global economy.

Biotechnology is providing a new frontier for agriculture, food, and forestry systems. To date, the genomes of many higher plants, microbes and insects are known. The significance of understanding this blueprint for life is just now being realized with the discovery of the genetic basis for growth and development, and disease. Purdue University scientists are leading the way in genomics, proteomics, metabolomics, and nanotechnology. In 2003, 16% of the field corn and 88% of the soybeans produced in Indiana were transgenic varieties. Purdue University researchers seek to understand and exploit the genetic basis for plant, animal, microbial and insect form and function. Fundamental and applied research in genomics, proteomics, molecular biology, and bioinformatics are the foundation for the development of value added/identity preserved products. Purdue University scientists are engaged in a wide array of genetic research including development of DNA vaccines for poultry and Arabidopsis gene function discover. Such discoveries can increase the profitability to farmers and the entire food value-chain by improving the productivity of crops and livestock, and adding value to agricultural products.

Plant productivity is challenged by numerous biological and non-biological stresses. Purdue University is making a significant investment in research to mitigate the impact of potential economic losses from pests and plant stress. Pests, such as the Western corn rootworm, have recently adapted and evolved to counter crop rotation as a biological control strategy, thus resulting in damage in first-year corn. Invasive species regularly enter agricultural system. The soybean aphid, first discovered in Indiana in 2000, became a major pest in northern Indiana in 2003. Purdue University researchers are exploring a variety of approaches to reduce potential pest losses including genetic resistance to pests, insect management on an areawide versus single field basis, biological control, and fewer chemical treatments by following Integrated Pest Management strategies.

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

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

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

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

Purdue University is providing Indiana farmers and businesses with opportunities to compete in new markets and obtain greater economic benefits. Purdue University research in this area is closely linked with our various stakeholders and extension educators around the state as together they seek to create new uses for agricultural products, while making more efficient use of natural resources and increasing the competitiveness of producers and agribusiness. One way this is being achieved is through the breeding or genetic modification of grain to make crops more valuable for food, processing, new materials, or energy production. The use of soy-diesel in increasing in Indiana, in part due to the research conducted at Purdue University, and its close collaboration with the Indiana Soybean Board. As a result of this relationship, the Indiana Soybean Board has generated financial support that will result in two endowed research chairs at Purdue University—one in soybean genetics and one in soybean utilization. Research programs are also addressing ways to use carbohydrates and oilseeds to make industrial products, such as substitutes for petroleum-based polymers, bio-based fuels, or enhancing the nutritional quality of grains for livestock. Other researchers are looking for new uses of agricultural products and by-products as feed for livestock and fish.

Successes:

- Emissions from swine and poultry buildings can be measured more accurately.
- Carbon sequestration under different tillage systems are being measured.
- Hay drying rates are not enhanced with investment in alternative style conditioning rolls.
- Feeding poultry pharmacological doses of copper from copper sulfate can greatly reduce phosphorus utilization.
- Improved forage can increase calf weaning weights and reduce the need to supplement with hay.
- Dietary acidification may be a viable alternative to antibiotics in nursery pig diets.
- Feeding ractopamine to swine requires gentle handling to minimize downers and deaths during transportation to market.
- A statewide survey found an abundance of soybean aphids in northern Indiana resulting in the development of economic thresholds for spraying.
- Gardeners who participated in workshops reduced insecticide applications and were more likely to adopt biological control methods.
- New public varieties of wheat were released with resistance to yellow dwarf virus.
- Understanding the role of an enzyme involved in phenylpropanoid secondary metabolism in Arabidopsis may lead to pulp wood that increases processing throughput with reduced chemical use.
- Studies of glucan synthesis and b-glucan content in grains such as wheat may result in a reduction in serum cholesterol as well as create new cereal products for the food industry.
- While an areawide pest management approach to control corn rootworms may not be economically viable, there is considerable interest among Indiana growers to adopt transgenic varieties with resistance to the corn rootworm.

- Techniques to establish seeded zoysia may lead to improved fairways with reduced irrigation, fertilizer, and pesticide use.
- Genetic studies are helping develop wheat varieties with resistance to head blight.
- A corn-soybean rotation with fall chisel tillage increases the availability of manganese relative to no-till and continuous corn.
- Fungicide sensitivity profiles will help golf course superintendents apply fewer fungicides to control dollar spot.
- Several alternative insecticides show promise to replace organophosphates currently being used and still maintain effective control of codling moth in apple orchards.
- A novel lighting system may save energy and enhance controlled-environment production of salad greens and culinary herbs.
- DNA vaccination technology offers a new approach to control infectious bursal disease in chickens.
- Genetic markers are being identified to assist in the selection of layers or broilers with stronger legs.
- Efforts to understand oocyte metabolism should increase the efficiency of reproductive technologies in livestock, with additional applications to human infertility and biomedicine.
- Phytase in pig diets can reduce phosphorus excretion.
- Most Midwestern elevators have the necessary grain receiving and alternative capacity storage bins to identity preserve grain.
- Information on the environmental and health benefits of GM food can increase consumer acceptance.
- Test kits to evaluate in 15 minutes the storability of shelled corn are being validated.
- Cross-pipes for furniture construction will reduce costs, allow the use of smaller-diameter timber, and could become a cottage industry in developing countries.
- A technique to produce slowly digesting starches may be beneficial to diabetics, and help reduce obesity.

Benefits:

- Using an economic threshold to spray soybean aphids at 200-400 aphids per plant can lead to a yield protection of about 25% or 12 bushels per acre.
- Newly released public wheat varieties with resistance to yellow dwarf barley virus should increase yields by 15-35% compared to available commercial varieties.
- Poplar trees transformed with cinnamate 4-hydroxylase ferulate 5-hydroxylase could increase pulp mill throughput by greater than 60%.
- Recently released apple and pear varieties through GardenAlive! will provide new fruit cultivars for Midwestern homeowners and commercial producers.
- Alternative insecticides can reduce codling moth pressure and organophosphate applications.
- Adoption of intra-canopy and close-canopy light-distribution systems in controlled environment production of salad greens and other horticultural crops in winter months will save energy.
- Marker genes will enhance the selection of chickens for bone mineral density and other economically important traits in egg-laying hens and broilers.
- Understanding of oocyte metabolism will allow for transgenics and cloning in livestock production, and help treat infertility in humans.
- Feeding Paylean™ to swine can increase profts about $9,000 per 1000 head finishing facility.
- Sorghum-based foods that are more digestible are critical for vulnerable infants in Africa.

State Assessment of Accomplishments:

Research at Purdue University continues to address the needs of various diverse stakeholders along the entire value-chain from input suppliers to farmers to processors to retailers to the final consumers at home and abroad. Research spans a very broad base, including, developing animal diets to reduce adverse environmental impacts from waste; evaluating new technologies as tools for agricultural competitiveness; evaluating contractual and structural options for producer competitive positioning; increasing the efficiency of plant growth, and developing the base for value added products that have the potential benefits for consumers and producers.

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

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

a. *Description:* Hay production in the Midwestern United States can be very challenging because of frequent rainfall, cloud cover, and high humidity. This research evaluated whether an alternative style of mechanical conditioning rolls, non-intermeshing, as compared to the traditional style, non-contacting and intermeshing, mechanical conditioning rolls improved hay drying rates. Use of a hay tedder with each type of conditioning treatment was evaluated for its effects upon hay drying rates, too. The research was conducted during the 2001 and 2002 haying seasons in Miami County, Indiana. The study was conducted on alfalfa, orchardgrass and an alfalfa/orchardgrass mixture. The weather factors of air temperature, vapor gradient, wind speed, and solar radiation determined the potential evapotranspiration rate as calculated by the Penman-Monteith equation. Moisture loss per hour for each treatment was compared to the potential evapotranspiration rate. Results of the study found that the alternative conditioning rolls with and without tedding did not significantly improve hay-drying rates as compared to the traditional conditioning rolls with and without tedding. A linear hay drying rate model for each forage type was developed to determine the moisture loss per hour based upon the potential evapotranspiration rate. These models can be used as a tool for predicting amount of time it will take for the hay to dry based upon weather conditions.

b. *Impact:* It is not economically justifiable for farmers to purchase the alternative style of conditioning rolls as they are more expensive than the traditional conditioning rolls and did not improve the hay drying rate for alfalfa, orchardgrass, or a mixture of the two forage types. The hay drying rate models developed warrant evaluation on a large number of hay harvests to see how reliable they are in predicting hay drying times.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Eastern Corn Belt

Key Theme: Invasive Species (1)

a. *Description:* The soybean aphid, *Aphis glycines Matsumura,* is a new invasive pest of Indiana soybeans. Multi-state collaborations is helping to define sampling protocols, economic thresholds, aphid-natural enemy ecology, and primary-secondary hosts associations. An economic threshold level of ca. 200-400 aphids/plant seems to be a reasonable approximation. Once the threshold is identified, further refinement of sampling protocols can proceed. The impact and ecology of endemic natural enemies were intensively studied in a field in Tippecanoe County and extensively examined using data from the statewide sampling effort. As in past years, the predominate natural enemy was *Orius insidious*, although other predators, particularly *Harmonia axyrides* were abundant later in the season. There was little evidence of parasitism, but fungal disease epidemics were relatively common. Predators present in the field before aphids arrive can have a significant effect on subsequent aphid densities, however. This impact is influenced by the presence of alternative prey such as whiteflies and thrips. The Field Crops Pest Management Project

evaluated the impacts of planting date and insecticide application on aphid colonization. A cool early season diminished the affect of planting date. Insecticide application at the estimated thresholds resulted in yield protection of 11.8 bushels per acre (26.2%). A state-wide survey indicated that the aphid was present throughout Indiana with greatest abundance in the northern counties.

b. *Impact:* Prior to the invasion of the soybean aphid, soybeans in the North Central Region typically did not suffer intense pressure from insect pests. The infestation of the aphid that now extends over a 20 state area challenges pest managers to develop new approaches to managing this serious pest of soybean production. Among critical questions have been the relative role natural enemies play in aphid dynamics and whether large-scale patterns of soybean aphid infestations relate to within field (e.g., natural enemies, variety, planting date) or extra-field (e.g., climate, alternative host plants, etc.) conditions. Insight into the relative contributions of within and extra-field conditions will serve as guideposts to how to approach aphid management and the tactics and strategies to adopt.

c. *Source of Federal Fund:* Hatch, NRI

d. *Scope of Impact:* Midwestern United States

Key Theme: Plant Production Efficiency (1)

a. *Description:* A novel crop-lighting system is being developed for controlled-environment agriculture (CEA). The high cost of lighting crops with artificial lamps as a sole light source has prevented CEA from being profitable. The problem is that foliar canopies of many crops "close" with respect to overhead light penetration, leading to mutual shading of lower leaves. Thus, it becomes necessary to operate lamps at high intensity to maximize crop-stand productivity. The associated heat load requires substantial spatial separation of lamps and crop surfaces, with a transparent heat-shield barrier imposed between them. Substantial energy must be expended for heat rejection from the system. The separation also causes an exponential decrease in incident radiation at the crop surface with linear distance between lamps and crop. Low-power "intra-canopy" (IC) and "close-canopy" (CC) light-distribution systems close to or touching plants without causing thermal tissue damage will overcome these problems. The IC light-distribution system consists of thin, vertical strips of composite material densely populated with parallel rows of tiny, colored, light-emitting diodes (LEDs). Crop plants grow among these hanging "lightcicles", which switch on in discrete, small sections from the bottom up, keeping pace with increases in canopy height. Switching is to be automated so that light energy is not wasted on empty headspace. LED colors will be selected to match absorption spectra of major plant pigmants. Color intensity from LEDs within discrete rows will be controlled separately, but the close spacing of rows permits effective spectral blending so that hue control as well as overall photon flux from the LED strips is effectively controlled by regulating electrical current to each color of LED. For low-profile and open-canopy crops, horizontal plates populated densely with small LEDs will be positioned close above crop stands. These "bulls-eye glowplates" will switch on in concentric circles or in irregular patterns above seedlings. The sensing and switch-control software will be more complex for the glowplates than for the lightcicles, but the spacing, switching, hue, and intensity control parameters will be completely analogous for both light-distribution systems. Design parameters have been defined and preliminary measurements of photon flux and temperature as a function of applied current and distance have been completed for printed-circuit LED arrays. Spectroradiometric scans of light output at different current intensities have been performed to test for spectral shifts at different power levels.

b. *Impact:* Development of intra-canopy and close-canopy light-distribution systems will save considerable power and energy for crop production in controlled environments. It will permit year-round crop production in warehouse environments in northern climates, especially if coupled with cheap, bio-derived energy sources. The combination will make commercial controlled-environment production of salad

greens and culinary herbs competitive with field-grown imports in the winter and will ensure high-quality produce year-round.

- *Source of Federal Funds:* Hatch, NASA

- *Scope of Impact:* Multiple states

Key theme: Animal Production Efficiency (1)

- *Description:* Forty-eight pigs were used to evaluate the effects of feeding low phytic acid (LPA) corn, LPA soybean meal, normal (NRM) corn, NRM soybean meal, and phytase on P digestibility and excretion. Pigs (BW = 45.3 kg) were blocked by BW and ancestry and assigned to the dietary treatments (TRT) in a 2x2x2 factorial arrangement. Pigs were fed twice daily (0700 and 1700 hr) at 3 times maintenance requirement for energy (NRC, 1998). Phytase was added to the diet at 510 PU/kg of feed and all diets were formulated to provide 0.38% total P, 0.50% Ca, and 1.0% Lys with no supplement P. Pigs were adapted to metabolism crates and TRT for 5 to 7 d followed by a 3-d total collection of urine and feces. Fecal P excretion was reduced 11% for pigs fed LPA corn vs NRM corn, 2.87 vs 3.22 g/d, 17% for pigs fed LPA soybean meal vs NRM soybean meal, 2.74 vs 3.34 g/d, 18% for pigs fed phytase vs non-phytase diets, 2.74 vs 3.35 g/d and 43% for pigs fed LPA corn, LPA soybean meal, and phytase vs NRM corn, NRM soybean meal without phytase, 2.13 vs 3.76 g/d. Phosphorus digestibility was increased 21% for pigs fed diets containing LPA corn vs NRM corn, 48.3 vs 39.9%, 16% for pigs fed LPA soybean meal vs NRM soybean meal, 47.3 vs 40.9%, and 22% for pigs fed phytase vs non-phytase diets, 48.5 vs 39.7%, respectively. Corn type and soybean meal type had no significant effect on water-soluble phosphorus (WSP) excretion. However, pigs fed diets containing phytase had less total WSP excreted than those without phytase inclusion, 1.96 vs 2.29 g/d.

- *Impact:* Using phytase in pig diets can significantly reduce phosphorus excretion while maintaining pig growth and productivity. Pork producers can significantly reduce land requirements for manure application, enhance water quality by reducing the threat of phosphorus pollution, and maintain profitable pork production compatible with environmental stewardship.

- *Source of Federal Funds:* Hatch, IFAFS

- *Scope of Impact:* Multi-state

Key theme: Animal Production Efficiency (2)

- *Description:* Understanding swine behavior and stress under different management systems is important. Sixteen pens (8 control and 8 fed ractopamine) of 6 pigs each were compared to determine how ractopamine (a beta-adrenergic agonist) altered physiology and behavior. Pigs fed ractopamine were more difficult to move and had higher heart rates during transportation.

- *Impact:* Feeding ractopamine to swine indicates that these animals require gentle handling to ensure that they reach market with the minimum number of downers and deaths during transportation.

- *Source of Federal Funds:* Hatch

- *Scope of Impact*: Multi-state

1.B. Genetic Resource Development

Key Theme: Animal Genomics (1)

a. *Description*: The quality and quantity of muscle growth is an important feature of agricultural animals used as a food source. This research investigated basic molecular mechanisms of muscle growth that have the potential to enhance muscle accretion and meat quality, and enhance muscle and bone recovery from disease states. Electroporation was used to ectopically express two potentially anti-atrophic proteins, IGF-I and Shh in the muscles of chickens. Expression of these proteins in the gastrocnemius/soleus muscle significantly stimulated muscle fiber hypertrophy and increased the muscle size. These proteins also attenuated the lost of muscle fiber area, muscle mass and muscle mass density that normally occurs during disuse muscle atrophy. In addition, ectopic expression of IGF-I and Shh within the gastrocnemius/soleus muscle inhibited parameters of osteopenia within the tibia and fibula associated with hind limb unloading. These results support the theory that skeletal muscle can regulate bone maintenance and could offer potentially novel and efficient therapeutic options for attenuating muscle and bone atrophy during aging, illness and spaceflight.

b. *Impact*: This work has the potential to identify molecules that can enhance muscle accretion and meat quality, and enhance muscle and bone recovery from disease states.

c. *Source of Federal Funds*: Hatch, NRI

d. *Scope of Impact:* Multi-state

Key Theme: Plant Germplasm (1)

a. *Description: Fusarium* head blight resistance QTLs were identified in wheat line F201R, on chromosomes 1B, 2A, 3D, and 5A; and in wheat line Ning 894037, on chromosome 3BS. A *Fusarium* head blight resistance QTL of strong effect was also identified on chromosome 7el2 in a wheat-Lophopyrum translocation line. These *Fusarium* head blight resistance QTLs are of great importance in wheat breeding to develop cultivars that have highly effective resistance against *Fusarium* head blight. The soft winter wheat germplasm line, P921696, was released that has gene H31, located on chromosome 5BS, and which confers resistance to biotype L of the Hessian fly. Three soft winter wheat cultivars were released: INW0301, INW0304, and INW0315. INW0301 has genes H9 and H13, Lr37, Sr38, Yr17 and is early maturing. INW0304 has type 2 resistance to *Fusarium* head blight and is early maturing, and INW0315 has yellow dwarf virus resistance from intermediate wheatgrass.

b. *Impact:* There is increasing evidence that there are few *Fusarium* head blight resistance QTLs in bread wheat that have large resistance effects, given that many of the resistant wheat lines studied to date have common resistance QTLs. The *Fusarium* head blight resistance QTL on chromosome 7el2 of Lophopyrum elongatum, identified in a wheat-Lophopyrum translocation line, has a large effect and is unique. Thus, this resistance QTL should be valuable to pyramid with other *Fusarium* head blight resistance QTL from wheat to result in highly effective resistance. Yellow dwarf virus resistance has not been identified in bread wheat, whereas a highly effective resistance has been identified in intermediate wheatgrass, a common pasture grass in the Western United States. The highly effective yellow dwarf virus resistance of intermediate wheatgrass that has been transferred to the soft red winter wheat cultivar INW0315 will significantly reduce production losses due to this devastating virus disease. INW0315 was competitive for grain yield with other commercial wheat cultivars in 2001 and 2003, seasons in which yellow dwarf virus was neglible, but INW0315 produced 15% to 35% more grain yield than other

commercial cultivars in 2002, a season in which yellow dwarf virus was severe throughout the eastern United States.

c. *Source of Federal Funds*: Hatch, IFAFS

d. *Scope of Impact*: Eastern United States

Key Theme: Plant Germplasm: (2)

a. *Description:* Alfalfa (*Medicago sativa L.)* is the most widely grown perennial forage legume in North America. The crown and taproot of alfalfa are the perenniating structures that enable this species to tolerate defoliation and environmental stresses by accumulating organic reserves, and remobilizing these reserves when stresses are relieved and shoot growth can resume. Vegetative storage proteins (VSPs) in alfalfa taproots are key among these reserve materials because they supply regrowing shoots with their nitrogen (N) needs during early regrowth when nitrogen fixation by this legume cannot meet plant N demands. Analysis of the physiological and biochemical features of taproot VSPs reveals: 1. VSPs can exceed 40% of the taproot soluble protein pool. 2. Labelling studies have revealed rapid and extensive transport of 15N from taproot VSP pools to regrowing alfalfa shoots during the initial 10 d after shoot removal. 3. Shoot regrowth rate after herbage removal is positively associated with taproot VSP abundance. 4. VSPs are located exclusively in taproots. They are not present in leaves, stems, fine lateral roots, or root nodules. Within taproots, VSPs are deposited in vacuoles of parenchyma cells. 5. VSP deposition in alfalfa roots is developmentally regulated. There are no VSPs in young roots, but rapid VSP accumulation begins about 8 weeks after emergence. 6. VSPs are found only in perennial species of *Medicago*. Immunoblotting analyses reveal that roots of annual Medicago species, including the model legume *Medicago truncatula*, are devoid of these VSPs. These studies clearly indicate that alfalfa taproot VSPs represent a key adaptation used by this perennial species to survive winter and periodic defoliation in summer when harvested for hay.

b. *Impact:* The identification of how VSP synthesis is regulated will broaden our understanding of VSPs relative to N reserve synthesis and utilization in alfalfa, and root gene expression in general. Ultimately, our experiments will advance our understanding of VSP synthesis, from molecular through agronomic perspectives. This information on the functional biology of alfalfa is needed if we are going to use modern molecular approaches for alfalfa improvement.

c. *Source of Federal Funds:* Hatch, IFAFS

d. *Scope of Impact:* Multi-state

Key Theme: Plant Genomics (1)

a. *Description:* The end products of the phenylpropanoid pathway play important roles in agriculture and human health. Examples of these compounds include phytoalexins, UV protectants, cell wall polymers, and substances that are now referred to as "neutraceuticals". Over the past twelve months an enzyme involved in phenylpropanoid secondary metabolism in Arabidopsis, and the pulping characteristics of transgenic poplar over-expressing the Arabidopsis gene for ferulate 5-hydroxylase, were analyzed. Serine carboxypeptidase-like (SCPL) proteins that catalyze transacylation reactions in plant secondary metabolism have been identified from wild tomato and Arabidopsis. These include sinapoylglucosecholine sinapoyltransferase (SCT), an enzyme that functions in Arabidopsis sinapate ester synthesis. SCT and the other known SCPL acyltransferases all share the conserved serine, aspartic acid, and histidine residues employed for catalysis by classical serine carboxypeptidases, although the

importance of these residues and the mechanism by which this class of SCPL proteins catalyze acyltransferase reactions is unknown. To further characterize SCT and its catalytic mechanism, the Saccharomyces cerevisiae vacuolar protein localization 1 mutant, which secretes the serine carboxypeptidase, carboxypeptidase Y, and other proteins normally targeted to the vacuole were analyzed.

b. *Impact:* Directed manipulation of the wood chemistry of trees could have huge impacts on both environmental and economic aspects of the pulp and paper industry. Consequently, a considerable amount of effort has been devoted to the modification of lignin, a cell wall component whose removal is a major part in chemical pulping. Analysis of poplar transformed with a cinnamate 4-hydroxylase (C4H) ferulate 5-hydroxylase (F5H) construct demonstrated significant increases in pulping efficiency from greenhouse grown trees. Estimations from these results indicate the C4H-F5H transformed trees could increase pulp throughputs at the mill by greater than 60%, while concurrently decreasing chemicals used in the pulping process, and the amount of deleterious pulping by-products released into the environment.

c. *Source of Federal Funds*: Hatch, NSF, DOE

d. *Scope of Impact:* Global

Key Theme: Plant Genomics (2)

a. *Description:* Using Arabidopsis and maize as genetic models, and a Fourier transform infrared spectroscopy, uncovered mutations that affect cell-wall composition and architecture. In other work, we discovered that the synthase of a growth-specific mixed linkage b-glucan is to be the topologic equivalent of cellulose synthase at the Golgi apparatus. We have kinetic data, and data from activity modification by proteases and mild detergent treatment to indicate that a distinct glycosyl transferase is associated with a core synthase to generate the unique mixed-linkage structure. Through structural and physiological characterization of mutants in xyloglucan structure, we established a role for the xyloglucan-modifying enzyme XET in maintenance of tensile strength during cell growth.

b. *Impact:* Heart disease is the second leading cause of death in the United States. Mixed-linkage b-glucan, a polymer only found in grass-like species, is the causal agent in the ability of brans to lower serum cholesterol in humans and insulin demand by diabetics. Studies of glucan synthesis and b-glucan content in glucan-poor grains, such as wheat, may result in modified cereals as a source of important dietary fiber that reduces serum cholesterol as well as make new cereal products for the food industry.

c. *Source of Federal Funds:* Hatch, NSF, DOE

d. *Scope of Impact*: Global

Key Theme: Plant Production Efficiency (1)

a. *Description:* Two apple and one pear varieties were released in 2003. Sundance (Co-op 29) is a late-season blushed yellow apple ripening 2-1/2 weeks after (Delicious). The fruit is large in size, attractive in appearance, and has outstanding spicy flavor and crisp texture. It contains the Vf gene for resistance to apple scab derived from Malus floribunda 821 and exhibits resistance to cedar apple rust and fireblight with moderate resistance to powdery mildew. Pixie Crunch (Co-op 33) is a midseason, high-quality, scab-immune (Vf) , red apple that has excellent appearance ripening a week before (Delicious). The fruit is small to medium in size and has a crisp texture with outstanding flavor that will appeal to children and adults alike. Green Jade (P448) is an early, productive large green/rusted pear with some tolerance to

fireblight that ripens in August. The ripened fruit is pleasant to eat either when firm or soft and should be suitable for home gardens and farm markets.

b. *Impact:* The recently released apple and pear varieties are being commercialized by Gardens Alive! and will provide new fruits for the Midwest. They should meet the demand for home owners and commercial fruit growers to produce high quality disease resistant cultivars.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Midwestern United States

Key Theme: Biotechnology (1)

a. *Description:* Mutagenized Arabidopsis populations were visually screened for new cuticular wax mutations. Gas-chromatography was used to screen for mutants having altered wax composition. Six new eceriferum mutants were identified from Arabidopsis enhancer-tag mutagenized populations. TAIL-PCR has been used to clone plant flanking sequences for five of these mutants, and putative functions have been assigned to the respective tagged genes based on sequence analysis alone. The WAX2 and RST1 genes from these mutants using multiple mutant alleles acquired from the SALK sequence tag populations have been identified. WAX2 appears to encode a metabolic enzyme of unknown function. RST1 encodes a large but completely novel protein. Both WAX2 and RST1 show multiple pleiotropic effects in overall development, including effects on fertility, seed production, and perennial growth patterns.

b. *Impact:* New knowledge about gene control over cuticle synthesis and overall plant development will be useful for designing novel approaches to genetically engineer crop plants for improved stress tolerance, especially to drought and pathogens. Recent studies indicating wax gene involvement in vegetative and reproductive development are shedding light on the potential of these genes to modify agronomically valuable developmental traits, including perennialism and seed production.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Global

Key Theme: Plant Health (1)

a. *Description:* Several registered and experimental fungicides reduced incidence of *Fusarium* head blight of wheat, as well as the number of *Fusarium*-damaged kernels and contamination of grain by deoxynivalenol. Corn residue is the major source of inoculum for wheat. Differences in residue density did not affect the intensity of head blight. Early in the season local differences in residue density were reflected by the number of ascospores of the pathogen in the air above the residue; later the spore numbers were the same regardless of residue density, suggesting that a uniform population of airborne spores was present over a wide area. Weather was favorable for head blight and, as hypothesized, this largely obscured differences in local inoculum density. Head blight variety trials at four research farms ranged from severe to mild. There was no correlation between head blight symptom intensity and visible damage to kernels or content of deoxynivalenol in grain. Many apparently healthy kernels were infected by *F. graminearum*. These infections may have occurred later than normal, at a time when grain was near full development. Weather-based disease risk prediction models underestimated the amount of head blight at most locations. Data from multiple sites gathered this year will permit refinement of these models.

b. *Impact: Fusarium* head blight is a major wheat disease in the Midwestern United States. Fungicide trials are providing efficacy data that may lead to registration of products that will provide some control. Data from epidemiology studies have been used to develop disease risk assessment models, which were used this year to predict an outbreak of head blight, which did in fact develop in central and southern Indiana. The models also correctly predicted that head blight would not be a problem in northern Indiana. Information from genetic studies is being used in wheat breeding programs to develop wheat cultivars with partial resistance to head blight.

d. *Source of Federal Funds:* Hatch, NRI, NSF

d. *Scope of Impact:* Midwestern United States

1.C. Plant Stress Management

Key Theme: Urban Gardening: (1)

d. *Description:* During 16 one-day workshops held in nine locations in Indiana and Illinois between January and April from 1998-2002 534 Master Gardeners. The workshops focused on two key aspects of biological control; its use as an alternative to insecticides in the home vegetable garden, and methods for testing its efficacy. Displays of both live and preserved specimens of natural enemies were used to show examples of natural enemies that can be found or purchased for use in the home garden. Participants learned about the research process, how to design experiments, compare treatments and evaluate results. During the research season these volunteers were supported using contacts via telephone, the Internet, and U.S. mail and personal visits. Most participants were college educated, were not involved in commercial agriculture or horticulture, were Master Gardeners, and lived in urban areas. There was a significant reduction in the number of participants using conventional and alternative pesticides up to 2 years after training. Gardeners who reduced the number of insecticide applications and participated in research were more likely to adopt biological control than those gardeners who either did not participate in research or did not reduce their use of insecticides. Our study suggests that while a necessary condition, pesticide reduction in itself will be insufficient to increase rates of biological control adoption. The second step, participatory research, provides gardeners an opportunity to investigate biological control options that they may then tailor to their own garden needs. This two-step process provides Extension specialists an opportunity to change gardener practices without requiring specific solutions to all possible combinations of crop-pest-natural enemy relationships. Enlisting gardeners in developing solutions to their pest problems has the potential to extend the impacts of Extension programs by increasing the number and diversity of pest management and other horticultural options available to gardeners.

d. *Impact:* Master gardeners replaced their pesticide use for biological control after participating in a hands-on workshop and conducting research in their home gardens. Home gardeners can use the program website to find solutions to their pest problems that do not require pesticide use. Extension Educators who put on these workshops can use the website to download all training materials and a teacher manual.

d. *Source of Federal Funds:* Hatch, Smith-Lever

d. *Scope of Impact*: Multi-state

Key Theme: Agricultural Profitability (1)

a. *Description:* The evolution of a Western corn rootworm variant in central Illinois and northern Indiana has increased farmers reliance on soil insecticides. Since the variant lays eggs in corn and soybean fields, crop rotation has become an ineffective means of controlling rootworms in first-year corn. With increased use of soil insecticides, insect resistance is a concern. In addition, organophosphate insecticides, which are generally the most effective at controlling rootworms and many other insect pests, are currently being scrutinized by the Environmental Protection Agency. Due to the need for alternative corn rootworm control measures, an Area Wide Pest Management Program (AWPM) research effort was organized by the Agricultural Research Service of the USDA in collaboration with several land-grant universities. The AWPM approach is based on suppressing the overall insect population below economically damaging levels by scouting and spraying fields with a semiochemical bait. This AWPM research effort was administered on a sixteen-mile square area at three different locations: Kansas, Iowa, and Indiana/Illinois. Data have been collected on these sites since 1997. Net Present Value analysis over an eight-year time horizon (1997-2004) suggests AWPM is not as profitable as traditional soil insecticides alone in regions of the Eastern Corn Belt where the variant is present. At an average market price of two dollars per bushel, the profitability gap between AWPM and soil insecticide alone is about $14-$28 per acre, depending on the level of corn rootworm pressure. Scouting fewer fields at an economic threshold in soybeans greater than two beetles/trap/day can result in $12-$17 per acre savings.

b. *Impact:* An Areawide approach to corn rootworm control appears to be economically viable in portions of the Western Corn Belt, but not the Eastern Corn Belt where the Western corn rootworm variant is present. Perhaps by scouting fewer soybean fields with a threshold greater than 2 adult beetles/trap/day, the areawide approach would be economically competitive with soil insecticides or recently approved transgenic corn varieties with resistance to corn rootworms.

c. *Source of Federal Funds:* Hatch, ARS

d. *Scope of Impact:* Midwestern United States

Key Theme: Ornamental/Green Agriculture (1)

a. *Description:* The transition zone in the United States where cool-season turfgrasses do not thrive because of summer weather while warm-season grasses do not thrive because winters are often too harsh extends from Kansas to Washington, DC. Zoysiagrass is the most well-adapted turf species for golf course fairways and tees in the southern quarter of Indiana as well as throughout the transition zone of the United States. Zoysiagrass requires less water, nitrogen, mowing, and pesticide inputs than any of the cool-season turfgrasses currently used in the transitions zone. Even though zoysiagrass is a warm-season grass, it has excellent winter survival and winter playability in the transition zone. Zoysiagrass has traditionally been established via sod which is extremely expensive, costing up to $15,000/acre. Thus, most golf courses cannot afford the initial expense of zoysia even when the long-term savings in maintenance is considered. Seeded zoysiagrass has recently become available on a limited scale and has reduced the cost of establishment by 80-90%, but little is known about its establishment. It has been determined that seeding 1-2 lbs zoysia/1000 sq ft is optimum, starter fertilizer at seeding is important while post-seeding fertilizer is less important, and monosodium methanearsonate (MSMA) applied 14, 28, and 42 days after seeding or MSMA plus dithiopyr applied 14 days after seeding provides optimum weed control and thus maximum establishment.

b. *Impact:* Refinement of these techniques for establishing seeded zoysia should lead to the increased use of zoysia. Zoysia fairways will reduce input use and costs of managing golf courses compared to the grasses currently used. Reduced use of irrigation, fertilizer, and pesticides will create more sustainable and environmentally friendly golf courses.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Eastern United States

Key Theme: Ornamental/Green Agriculture (2)

a. *Description:* Investigation of the epidemiology of gray leaf spot of perennial ryegrass demonstrated that the pathogen will over-winter on infested residue in north central Indiana, but population levels are too low to contribute to epidemics during the summer. It appears that the experimental site exists within a transition zone between a southern region (Ohio Valley and lesser latitudes) where gray leaf spot outbreaks are chronic; and a northern region (all northern tier Midwestern states) where the disease has not been observed. A PCR method was developed for rapid identification of the pathogen in host tissues. A survey of isolates of *Sclerotinia homoeocarpa* from Indiana golf courses for sensitivity to three fungicides: iprodione, propiconazole, and thiophanate-methyl was completed. Results showed considerable insensitivity to all three fungicides exists in Indiana populations of *S. homoeocarpa.* Insensitivity (fungicide resistance) appeared to play a role in dollar spot outbreaks on several golf courses.

b. *Impact:* Knowledge regarding pathogen survival and the sensitivity of pathogen populations to common fungicides will result in more efficient use of turf chemicals and fewer, less severe disease outbreaks. Specifically, this information will help golf course superintendents who are weighing the advantages and disadvantages associated with an approach based on chemical control versus one involving serious renovation with non-host turf species. Also, using the fungicide sensitivity profiles, superintendents gain an awareness of the dollar spot threat on their own golf courses. As a result, they are likely to apply less fungicide while maintaining an attractive high quality playing surface.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Indiana

Key Theme: Plant Health (1)

a. *Description:* Many cultural practices influence soil-borne diseases by modifying nutrient availability or plant uptake efficiency. Research shows that crop rotation, crop sequence, and tillage influence manganese availability for plant uptake. Continuous corn had significantly more plant-available manganese than continuous soybeans at the end of the season. Corn in rotation with soybean and wheat also had higher available manganese, but was not as high as continuous corn. There are tillage-rotation interactions and manganese was more available with fall chisel tillage than no-till, and less available in wet than in drying soils. The effect of crop sequence and rotation appears to be more advantageous for soybeans than corn and could be especially important for low available-manganese soils predisposed to soil-borne plant pathogens.

b. *Impact:* Understanding how cultural practices influence soil-borne diseases provides a basis for biological control and mechanisms to enhance nutrient efficiency and reduce predisposition to disease.

c. Source of Federal Funds: Hatch, NRI

d. Scope of Impact: Indiana

Key Theme: Plant Production Efficiency (1)

d. Description: A five state study, including Indiana, Illinois, Missouri, Ohio, and Kentucky, was initiated to investigate the effectiveness of reduced-risk, alternative insecticides for control of codling moth in apples. Each state conducted the experiment in two locations, a university farm and in a grower orchard. The grower orchards were located at sites in which problems had been reported in controlling codling moths with organophosphate insecticides. At the Indiana grower site, the percentage of damaged fruit from first generation codling moth were Assail (2.0 a), Avaunt (7.3 c), Calypso (2.5 a), Danitol (3.7 ab), Esteem (5.9 bc), Guthion (1.3 a), Intrepid (5.6 bc), Spintor (3.1 ab), and the untreated control (8.3 c). At harvest at the Purdue University Horticultural Farm, the results were Assail (4.8 abc), Avaunt (12.0 cde), Calypso (3.2 ab), Danitol (2.0 a), Esteem (17.4 e), Guthion (2.0 a), Intrepid (7.6 abcd), Spintor (13.2 de), and the untreated control (46.8 f). Several of the alternative insecticides appear to show promise for replacing or reducing the use of the organophosphate insecticides. The attract and kill product, Last Call-CM, which uses pheromones mixed with a toxicant, was used in each state and, although the results varied, provided reasonably good control of codling moths. The sprayable pheromone formulation, CheckMate-CM, was used in a block of apples at a grower orchard, with commercially acceptable levels of control.

d. Impact: Apple growers will be able to select alternative strategies for control of codling moths. This should reduce the use of organophosphate insecticides and, in many cases improve control of codling moths.

d. Source of Federal Funds: Hatch

d. Scope of Impact: Indiana

Key Theme: Emerging Infectious Diseases (1)

d. Description: Biocontrol of Sudden Death Syndrome (SDS) of soybean, caused by *Fusarium solani f.sp. glycines*, recently renamed *Fusarium virguliforme*, is a soil-borne disease of increasing importance throughout the North Central Region of the United States. This late season disease is a combination of a root rot, leaf drop, and premature death of the soybean that leads to substantial yield loss. Commercial biocontrol organisms against soil-borne fungi were tested in vitro and in the greenhouse for antagonistic potential against *Fusarium solani f.sp. glycines*. A greenhouse bioassay was developed to test for biocontrol organisms for their potential to reduce severity of SDS. Soybean field soils were tested for soil suppressiveness against the disease.

d. Impact: Studies of the interaction of soil-borne pathogens and beneficial organisms will improve the implementation of sustainable management options for soil-borne diseases.

d. Source of Federal Funds: Hatch

d. Scope of Impact: Multiple states

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

Key Theme: Animal Health (1)

a. *Description:* This research explored the feasibility of using DNA vaccination technology against infectious bursal disease virus (IBDV) infection in chickens. The traditional approach to vaccine production is to use the entire virus in a killed or modified form or to use protein antigens from the virus. This research showed that is was possible to induce an antibody response and provide protection against IBDV by vaccinating with a DNA sequence against various genes of IBDV. The best protection was observed when chickens were vaccinated with a combination of genes and then challenged with a homologous strain of IBDV (100% protection). Vaccination with multiple gene combinations and then challenge with a heterologous strain of IBDV was less effective (55%). Both humoral and cellular immune responses were induced upon IBD DNA vaccination as evidenced by increased IBDV antigen specific antibody responses, increased delayed type hypersensitivity, and increased lymphocyte proliferation. In conclusion, DNA vaccination by injection of naked DNA coding for protective antigen without the presence of the entire virus provided adequate protection of chickens against IBDV infection. DNA vaccination technology is a potential new approach for successful vaccination against infectious bursal disease in chickens and will have a significant impact on the productivity and revenue of the U.S. poultry industry.

b. *Impact:* DNA vaccination technology is a potential new approach for successful vaccination against infectious bursal disease in chickens and will have a significant impact on the productivity and revenue of the U.S. poultry industry.

c. *Source of Federal Funds*: Animal Health

d. *Scope of Impact*: Multi-state

Key Theme: Animal Health (2)

a. *Description*: Growth of turkey coronavirus (TCV) in cell cultures is not an effective method for diagnosis of the disease. An antibody-capture ELISA was developed that utilized a recombinant structural protein of TCV. The nucleocapsid (N) protein gene of TCV was cloned and expressed and used as coating antigen for an antibody-capture ELISA. The optimal conditions for differentiation between anti-TCV and normal turkey serum was determined with 322 turkey sera from the field and the cutoff point determined. Among the 322 turkey sera, 101 were positive and 221 were negative for TCV by immunofluorescent antibody assay. The sensitivity and specificity of the ELISA relative to assay test were 86% and 95.6%, respectively, based on the ELISA results using the established positive cutoff point. The ELISA did not detect antibodies specific for bovine coronavirus, transmissible gastroenteritis virus, turkey adenovirus, avian rotavirus, avian reovirus, and enterovirus. The results indicate that purified recombinant N protein of TCV is useful as coating antigen for detection of antibody to TCV in antibody-capture ELISA and may provide a specific and sensitive method for rapid diagnosis and control of a TCV disease outbreak. In addition, a segment of spike protein gene of TCV was cloned and expressed and is currently being evaluated in the ELISA test.

b. *Impact*: The structural proteins and their genes of TCV can be utilized immunologically and molecular biologically as diagnostic reagents and vaccines for prevention and control of turkey coronaviral enteritis in the U.S. turkey industry.

c. *Source of Federal Funds:* Animal Health, USDA-CSREES Special Grant

d. *Scope of Impact*: Multi-state

Key Theme: Animal Health (3)

a. *Description:* Adequate provision of gluconeogenic precursors is crucial to the health of transition dairy cows. Non-forage fiber source (NFFS) diets reduce the severity of dry matter intake depression in transition cows and therefore provide more glucose precursors. Likewise, feeding monensin favors enhanced supply of propionate for gluconeogenesis. Twenty-one multiparous Holstein cows were used to determine the effects of NFFS and monensin on expression of gluconeogenic enzymes. Dietary treatments began at dry off and continued through parturition. Liver biopsy samples were obtained at -28, -14, +1, +14, and +28 d relative to calving and used to determine pyruvate carboxylase (PC) and phosphoenolpyruvate carboxykinase (PEPCK) mRNA expression. Expression of PC mRNA differed with prepartum diet, but there was no effect of diet on PEPCK mRNA. Feeding NFFS and monensin increased PC expression at calving. The data indicated that endproducts of rumen fermentation act to alter gene expression in liver of dairy cattle which may serve to regulate the metabolic fate of these nutrients.

b. *Impact:* Data from this project can be applied immediately to management practices for dairy cows and heifers during the transition to lactation. The experiments indicate that endproducts of rumen fermentation act to alter expression of genes in liver that control their metabolism. Feeding behavior data demonstrate that feed intake is important 7-10 days prior to parturition, but that a reduction in feed intake immediately prior to calving is not detrimental to milk production in the ensuing lactation.

c. *Source of Federal Fund:* Hatch

d. *Scope of Impact:* Multi-state

Key Theme: Animal Health (4)

a. *Description:* Postnatal changes in the maximal enzyme activity (V_{max}) and enzyme affinity (K_m) of jejunal mucosal membrane-bound alkaline phosphatase, aminopeptidase N and sucrase using a porcine model which may more closely resemble the human intestine were examined. Jejunal brush border membrane was prepared by Mg2+-precipitation and differential centrifugation from pigs of suckling (8 days), weaning (28 days), post-weaning (35 days) and adult (70 days) stages. p-Nitrophenyl phosphate (0 - 8 mM), L-alanine-p-nitroanilide hydrochloride (0 - 28 mM) and sucrose (0 - 100 mM) were used in alkaline phosphatase, aminopeptidase N and sucrase kinetic measurements. Vmax of alkaline phosphatase was the lowest in the adult (4.27 umol.mg-1 protein.min-1), intermediate in the suckling (9.75 umol.mg-l protein.min-l) and the highest in the weaning and post-weaning stage (12.83 and 10.40 umol.mg-l protein.min-l). Km of alkaline phosphatase was high in the suckling and weaning stages (5.14 and 9.93 mM) and low in the adult (0.66 mM). Vmax of aminopeptidase N was low in the suckling (7.04 umol.mg protein-1.min-1) and high in the post-weaning stage (13.36 umol.mg-l protein.min-l). Km of aminopeptidase N was the highest in the two weaning stages (2.96 and 3.39 mM), intermediate in the adult (2.33 mM) and the lowest in the suckling stage (1.66 mM). Vmax of sucrase increased from the suckling to the adult (0.48 - 1.30 umol.mg-l protein.min-l). Km of sucrase ranged from 11.19 to 16.57 mM. There are dramatic postnatal developmental changes in both the maximal enzyme activity and enzyme affinity of jejunal brush border membrane-bound alkaline phosphatase, aminopeptidase N and sucrase in the pig.

b. *Impact:* Dietary nutrients are not utilized very well by pigs and poultry. This is partly due to inefficient absorption of nutrients from the digestive tract and inadequate knowledge base on the genetic development of digestive functions. These results indicate dramatic postnatal developmental changes in both the maximal enzyme activity and enzyme affinity of jejunal brush border membrane-bound alkaline phosphatase, aminopeptidase N and sucrase in the pig. This research may help explain why pigs have trouble gaining weight on certain diets and eventually may help in reducing the cost of diets and the nutrients passed out in the manure.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impac* : Multi-state

Key Theme: Animal Health (5)

a. *Description:* Baseline emissions of odor, ammonia (NH3), hydrogen sulfide (H2S), carbon dioxide (CO2) and particulate matter (PM) from mechanically ventilated livestock buildings are being measured in collaboration with five other universities. The project is evaluating differences in emissions due to season of year, time of day, building design, growth cycle of the animals, and building management. Mobile laboratories housing continuous gas and PM analyzers are monitoring emissions from a pair of identical buildings for 15 months. Olfactometry is being used to measure odor emissions. A total of 150 barn-months of data are being collected from six animal housing systems including pig farrowing, gestation, and finishing buildings and chicken layer and broiler facilities. Emission tests also were conducted at two 1,100-head tunnel-ventilated swine finishing buildings in Missouri.

b. *Impact:* Measured emission rates of odor, hydrogen sulfide, particulate matter, ammonia, methane and non-methane hydrocarbons from swine and poultry buildings will provide needed information about air pollution and will be utilized by individuals and organizations throughout the United States.

c. *Source of Federal Funds:* Hatch, USDA-CSREES Grant

d. *Scope of Impact:* Multi-state

Key Theme: Animal Health: (6)

a. *Description:* A preliminary sampling of nursing piglets has been completed to evaluate the presence of *E.Coli* and salmonella. Twenty-four nursing piglets (2/litter) had fresh fecal samples collected to determine concentration of *E.coli* and the presence of salmonella. The average fecal *E.coli* concentration was 19.85 nlog CFUs/g and salmonella was observed in 8.3% of the pigs. Two nursery pig studies have been completed to evaluate the effectiveness of two dietary acid supplementations on pig performance and microbial shedding. Experiment 1 utilized 180 weanling pigs and Experiment 2 utilized 300 weanling pigs to evaluate the use of an organic acid blend (OA) and inorganic acid based blend (IA) in nursery pig diets (18 d of age). Both experiments had dietary treatments fed throughout the 35-d trial in three phases; phase1 (d 0-7), phase 2 (d 7-21), and phase 3 (d 21-35). Pigs were assigned to one of five dietary treatments in Experiment 1: 1) Basal diet, 2) Diet 1 + 50 ppm carbadox, 3) Diet 1 + 0.4% OA, 4) Diet 1 + 0.2% IA, 5) Diet 1 + 0.4% OA and 0.2% IA (OA/IA). There were no differences in ADG among the dietary treatments at any time during the study. The ADFI (d 0-35) for pigs fed the OA/IA diet tended to be lower than the ADFI of pigs fed all other treatments. The G:F of pigs fed Diet 1 tended to be lower than for pigs fed the carbadox diet. There was no effect of treatment on the presence of fecal salmonella. On d-6, pigs fed Diet 1 had lower E. coli counts than pigs fed any other treatment. At d 34, the E. coli counts for pigs fed the carbadox diet and the negative control were higher than pigs fed the OA/IA diet. Pigs were assigned to one of six dietary treatments in Experiment 2; Diets 1-4 from Experiment 1 and

Diet 5) Sequence 1; Diet 3 for 7 d followed by Diet 4 for 28 d, and Diet 6) Sequence 2; Diet 4 for 7 d followed by Diet 3 for 28 d. There was no effect of treatment on ADG, ADFI, or G:F during phase 1. During phase 2, ADFI of sequence 1 was higher than sequence 2 and tended to be higher than the OA diet. Pigs fed carbadox tended to have greater ADFI than pigs fed OA and sequence 2 treatments. During phase 3 and overall, pigs fed carbadox and sequence 1 diets had higher ADG than all other treatments and higher ADFI than all other acid treatments, and tended to have higher ADFI than Diet 1. In Experiment 1, the growth performance of pigs fed the OA and IA diets were similar to each other and the carbadox-fed pigs, however, OA and IA were lower in Experiment 2. Additionally, adding both OA and IA acids at these levels to the nursery pig diet reduced feed intake and pig growth rate in Experiment 1. In Experiment 2, pigs fed the acid sequence 1 diet had similar growth performance to pigs fed carbadox and this novel dietary acid sequence may have merit as a replacement for antibiotics in the nursery phase.

b. *Impact:* The use of a novel dietary acid sequence of a blend of organic acids followed by inorganic acids provided similar pig growth performance and reduced fecal E.coli concentrations compared to carbadox. This dietary acidification program may provide a viable alternative to antibiotics in nursery pig diets.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Multi-state

Key Theme: Animal Genomics (1)

a. *Description*: This research identified genetic markers to select chickens better adapted to the egg-laying or broiler industry. An F2 resource population of 519 hens was developed by crossing a layer (White Leghorn hens) and a broiler (Cobb roosters) line. The F2 chickens are currently being used to identify quantitative trait loci (QTL) influencing bone mineral density (BMD) and other economically important traits in chickens. The left tibia of grandparent female laying hens and female hatch mates of the broiler roosters used to generate the F2 resource population were scanned at 35 wk of age using a Norland pDexa bone densitometer. The BMD of the tibia was significantly greater in the broiler female line as compared to the layer female line. Grandparents of the F2 generation were genotyped for 147 microsatellite markers using the ABI3700 and ABI Prism Genotyper software. A total of 138 markers were informative with an average information content of 0.69. Additional traits of economic importance are also being measured in the F2 population, including egg production, shell thickness, shell puncture score, shell color, and the weight of the bird, egg, shell, yolk, and albumen. A complete genome scan using 138 markers is currently underway to identify QTL associated with BMD and other economically important traits in the F2 population of chickens.

b. *Impact*: The F2 population will facilitate the identification of genetic markers of bone mineral density and other economically important traits in chickens. Ultimately, these markers may be useful in selecting chickens better adapted to the egg-laying or broiler industry.

c. *Source of Federal Funds:* Hatch, NRI

d. *Scope of Impact*: Multi-state

Key Theme: Animal Production Efficiency (1)

a. *Description*: An understanding of oocyte quality is necessary for their successful use in reproductive technologies such as *in-vitro* fertilization, cloning and transgenic animal production, maintaining animal stock biodiversity, and for livestock production, human infertility and biomedicine. Oocyte metabolism

has been shown to be a good marker of oocyte quality. This is true of oocytes that will produce embryos by *in-vitro* fertilization or nuclear transfer. A defined maturation system has been developed for goat oocytes, as well as a system that decreases polyspermic fertilization in pigs. These refinements allow more successful testing oocyte quality.

d. *Impact*: This research will enhance our knowledge of basic oocyte biology. An understanding of the developmental processes within the oocyte will allow successful utilization of oocytes for *in vitro* fertilization, cloning and transgenic animal production. The results of this research will also increase the feasibility of using oocytes for livestock production, with additional applications in human infertility and biomedicine.

d. *Source of Federal Fund*: Hatch, NRI

d. *Scope of Impact:* Multi-state

Key Theme: Rangeland/Pasture Management (1)

j. *Description:* In the beef cow-calf enterprise, productivity is greatly impacted by forage quality and quantity. During the 2002 grazing season, low moisture conditions in southern Indiana beginning in July, limited pasture forage growth to the point that supplemented hay feeding was required. At the Feldun-Purdue Agricultural Center calf weaning weights were 60-901bs less than in previous years. Also apparent was that calf weaning weights seemed to vary greater among pastures differing in forage type than in previous years. These conditions and observations provided the opportunity to evaluate what effect, if any, pre-weaning calf growth might have upon post-weaning feedlot performance, carcass merit and value. A total of 116 spring born steer calves and their dams were grazed on six pastures that differed in forage quality and quantity. Pasture forage type ranged from endophyte infected tall fescue (TF) and legumes to low endo-endophyte TF and orchard grass (OG) and legume. The legumes were either red and white clovers or alfalfa. Calves were crossbred and breedtype (55% Angus, 41% Simmental and 4% Polled Hereford breeding on average) was comparable among all pastures. Calf dams ranged from first calf heifers to mature cows. While on pasture (April to October) calf daily gains ranged from 1.82 to 2.55 lbs per day and were lowest for high-endophyte TF and highest for low-endophyte TF pasture groups. Calf weaning weights ranged from 503 to 675 lbs and calf body condition ranged from 4.8 to 5.4 (1-9, 5 = average) among pasture groups. At weaning, calves were transported to a post-weaning feedyard facility and were fed a common high energy corn based diet until harvest. Pasture groups were fed in separate pens throughout the post-weaning period. Daily gain ranged from 3.48 to 3.77 lbs per day and feed/gain 6.05 to 6.46. Cattle that were heavier at weaning reached harvest weight and condition in fewer days than lighter weight calves at weaning. Days on feed ranged from 191 to 231 among pasture groups. Carcass yield and quality grade was similar among pasture groups.

j. *Impact:* Pre-weaning nutritional environment resulting in differences in weaning weights of calves did not have a major impact on post-weaning feedlot performance or carcass merit. There was no apparent evidence of compensatory gain post-weaning, for lighter weight calves. Thus, to reach comparable harvest weight and condition, the feeding period for lighter weight calves must be extended. Traditionally, market prices tend to decline from early spring to mid-summer. Thus, an extended feeding period and delayed marketing due to calves being light weight at weaning could have a negative impact on their value at harvest.

j. *Source of Federal Funds:* Hatch

j. *Scope of Impact:* Indiana

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

Key Theme: Agricultural Competitiveness (1)

d. Description: The feeding of ractopamine –Paylean™- can substantially increase the efficiency of swine growth and profitability. The benefits of Paylean™ with improved feeding and optimal marketing management can generate a $7,000 to $10,000 increase in profitability per 1000 head finishing facility. One of the interesting results from the research was that it is optimal to adjust the Paylean™ level upward through the life of the pig, starting with a relatively low level and increasing it as the pig becomes desensitized to the lean growth enhancement from Paylean™.

d. Impact: Farmers will be able to make more accurate and optimal production and marketing decisions when they add ractopamine to their swine rations.

d. Source of Federal Funds: Hatch

d. Scope of Impact: Multi-state

Key Theme: Agricultural Competitiveness (2)

d. Description: A nationwide survey of commercial farmer buying behavior was conducted in February-April 2003. The questionnaire was based on an earlier questionnaire used for similar studies in 1993 and 1998 and covered three main areas: 1) the farm business; 2) the farm operator; and 3) decision-making processes. The third area was devoted to how the input purchasing decisions are made and included outside influence, information gathering, and buying behavior, among other topics. The questionnaire was mailed to 14,301 agricultural producers across the United States with 2,424 surveys returned for a response rate of 16.9%. Another survey explored the involvement of retail crop input dealers in the provision of precision agricultural (site-specific services). More than 450 dealerships across the U.S. responded to the questionnaire. Key findings suggest that expansion of site-specific service offerings resumed after slowing in 2000 and 2001. And, dealers continue to focus more heavily on site-specific services that do not require large capital outlays such as field mapping. 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 beginning to converge. Provision of these services is higher in the Midwest relative to other states, and more prevalent in cooperatives and larger national organizations relative to independent operations. Results suggest that many growers will have a number of possible sources of precision services to evaluate in the near term, and there will likely be considerable difference in both the services included in the bundle, and in the price of the bundle.

d. Impact: A survey of farmer buying behavior offers important insights into the current status and decision processes of today's commercial producers. Agricultural producers are interested in the trends and plans of their colleagues, while agribusinesses are interested in the outlook and purchasing decision processes of their potential customers. The precision agriculture survey developed and executed for this project provides the only publicly available data that benchmarks the adoption of precision agricultural services by retail crop input dealers. These data are widely used to better understand how dealers are managing the introduction of precision agricultural services.

d. Source of Federal Funds: Hatch

d. Scope of Impact: Multi-state

Key Theme: Agricultural Competitiveness (3)

- *Description:* The combination of rapid income growth in the developing countries, coupled with a dietary transition in which many of these households are adding more meat in their meals, ensures a strong surge in the global demand for meat in the coming two decades. How much of this will be supplied locally, and how much will be supplied via exports from the United States and elsewhere? The answer to this question depends heavily on productivity growth in the livestock sectors of the developing countries. Recent studies by USDA and others have been overly optimistic about the prospects for increased meat exports to China, in part because they confused rapid increases in trade volume with increases in the value of trade. China remains a $1billion net exporter of livestock products. It is still possible that China will become a net importer, but this will hinge critically on developments in on-farm productivity as well as increases in wages that might erode China's strong comparative advantage in meat processing.

- *Impact:* U.S. meat producers face a difficult problem in gauging the potential offered by the Chinese market in the coming decade. It is clear that demand for meat will grow rapidly, but supply is uncertain. Previous studies may have significantly over-stated productivity growth in China's livestock sector by focusing on simple measures of output per head. By taking into account other inputs used in livestock production, future productivity growth is likely to be more modest - thereby opening the way for increased Chinese meat imports.

- *Source of Federal Funds:* Hatch

- *Scope of Impact*: Global

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

- *Description:* Research focused on the quality of cereals and oilseeds during handling, storage and transport by assessing the effects of post-harvest practices on microbial growth, insect infestation, chemical usage, drying, handling, and processing. During the last several years, U.S. farm policy and global grain markets have been pushing the grain industry towards a quality-oriented marketing system. In order for a system of this type to function, the identity of grain must be preserved from the field to the country elevator to its final destination. Grain elevators need to segregate their incoming products into batches of different end-use quality (high oil corn, genetically modified soybeans, high protein wheat), but often they are not designed to handle this task efficiently. During 2002-03 a study was conducted to investigate how well 75 country elevators in Illinois, Indiana, Ohio and Michigan were able to segregate incoming crops. About 90% of the elevators surveyed have more than one receiving pit and bucket elevator. The majority (65%) of the elevators have more than 10 storage bins of less than 50,000 bushels and relatively few storage bins greater than 100,000 bushels. Given that most facilities have more than one receiving pit and multiple smaller storage structures, Eastern Corn Belt country elevators should be able to segregate multiple streams of grains successfully. The inability to successfully segregate multiple streams of incoming grains could generally be related to poor logistical management of incoming trucks during the harvest peak period, lack of trained personnel, and poor allocation of available resources, labor, equipment, and time.

- *Impact:* The results of a Corn Belt elevator survey are being used to develop an elevator simulation system analysis model.

- *Source of Federal Funds*: Hatch

d. Scope of Impact: Multi-state

Key Theme: Managing Change in Agriculture (1)

a. Description: Several experiments have been performed in the United States and Europe investigating consumers' attitudes toward genetically modified foods. The study looked at the effect of these preferences on trade policy and the determinants of consumer acceptance of genetically modified foods. Results indicate consumers in England and France would demand much greater compensation to consume genetically modified foods than U.S. consumers. These findings hold important implications for the positions of the United States and the European Union in international trade negotiations and point to a greater need for theoretical work incorporating heterogeneity in consumer preferences in models of international trade. Information on environmental benefits, health benefits, and benefits to the third world significantly decreased the amount of money consumers demanded to consume GM food; however, the effect of information varied by type of information and location.

b. Impact: This marketing research is assisting agricultural producers and agribusinesses in determining potential profitability of selling new goods or modifying existing products, especially the potential acceptance by U.S. and EU consumers of genetically engineered foods.

c. Source of Federal Funds: Hatch, NRI

d. Scope of Impact: Global

1.F. Value-Added

Key Theme: New Uses for Agricultural Products (1)

a. Description: An aviation deicer product has proven to be very promising commercially. The crude glycerol stream from methyl ester production has been shown to have equivalent or superior anti-deicer performance to existing commercial products from ethylene and propylene glycols. In addition to complete biodegradability, these glycerol solutions are also approximately 1/10th of the cost of EG/PG materials. Current work involves completing a marketing/life cycle analysis, product testing in wind tunnel and on 727 aircraft, and finally FAA certification. Home heating fuel that incorporates up to 30% de-gummed soybean oil in commercial heating fuels has been found to have a price advantage versus current petroleum-based fuels in existing commercial equipment with decreased sulfur oxide emissions.

b. Impact: The use of soybean oils and derivatives as replacements for petrochemical products and intermediates offers opportunities for rural development.

c. Source of Federal Funds: Hatch, USDA-CSREES Grant-IFAFS

d. Scope of Impact: Global

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

a. Description: Samples of shelled corn with a wide range of storage history and quality were evaluated for storability using different tests. Storability is defined as the resistance of the shelled corn to invasion by storage fungi. The tests included ppm ergosterol, percent kernel infection by plating, electrolyte leakage, and kernel damage. NIR tests were conducted to determine whether there are differences in NIR spectra that can be related to storability. The samples were re-wetted to 21% moisture and evaluated using a test

kit that has been adapted for measurement of carbon dioxide (CO_2) release by the samples. After 2 to 3 days of incubation, the primary source of CO_2 release is fungal activity. Results were analyzed to determine correlations among measurements and to determine which tests give the best indication of the storability of the samples.

b. *Impact:* Storability testing could be used by commercial elevators on lots of corn being shipped overseas that will be exposed to tropical or sub-tropical climates. Several tests are being evaluated to give storability values in 48 to 72 hours. Several tests that could be conducted in 15 minutes are also being evaluated to screen samples in situations where there is insufficient time to conduct the 3-day CO_2 kit test.

c. *Source of Federal Funds*: Hatch

d. *Scope of Impact:* Global

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

a. *Description:* Fried chips were made in a laboratory scale process in which yellow masa was sheeted, baked at 300 degrees C for 110 seconds and fried at 190 degrees C for 40 seconds. Excess oil was removed with absorbent paper. Oil content was determined by Soxhlet method. In wind tunnel experiments, a chip with a known amount of seasoning was placed in a rectangular channel through which air at known flow rate was flown and the amount of seasoning retained by the chip at different flow rates and angles of inclination were measured. Based on boundary layer theory, the average adhesion force of seasoning particle-chip surface was inferred. Results showed that particle-chip surface adhesion strength increases with increasing particle size (32-300 mu m), oil content (24-32%), viscosity (55.9-72.2 cP.) and surface tension (27.5 - 34.1 mN/m). Variation of calculated values of van der Waals, electrostatic and capillary forces for different particle size, surface tension and hydrophobicity were consistent with experimental observations. Comparison of experimental adhesion forces with calculated values indicated that electrostatic and capillary forces are more important.

b. *Impact:* The snack-food industry is more than $25 billion annual enterprise. Dry seasoning is applied to many snack products after they are either fried or baked in a tumbling mixer in order to enhance their flavor and taste. It is important to ensure uniform application of seasoning onto the product surface with minimum seasoning loss in order to maintain the quality of the final product. The information from this study can be used to develop product/process modifications to maximize the retention of seasoning for the manufacture of products with better quality at a reduced cost.

c. *Source of Federal Funds:* Hatch

d. *Scope of Impact:* Global

Key Theme: Biobased Products (1)

a. *Description:* Tests show that through-bolts with cross-pipe and nut connectors provide a simple inexpensive manner of connecting timber frame members. Tests also show that round mortise and tenon timber frame joints provide high levels of shear, bending, and withdrawal strength relative to the size of members joined together. Use of cross pipes instead of wood pins or dowels greatly increase the withdrawal strength of round mortise and tenon joints at no increase in cost. Also, cross-pipes provide a means of constructing trusses from small-diameter round timber. A wide variety of structures can be constructed from a relatively few modular parts. Thus, round mortise and tenon joints together with through-bolts with cross-pipe and nut connections provide a simple low-cost method of producing strong

dependable timber frames that form the basic structure for house, farm, and light industrial buildings along with schools from small-diameter timber. Further research shows that shoulders on tenons contribute greatly to the bending moment capacity of round mortise and tenon joints. Cyclic tests also indicate that cross-pinned tenons may be used instead of glued tenons in school furniture in disadvantaged regions provided the tenons are cut on members with high shear strength. This allows expensive adhesives to be omitted while structural integrity is ensured.

d. Impact: Strong, low-cost hurricane and earthquake resistant building frames can be constructed from small-diameter timber with simple low-cost equipment. This research provides a means of ensuring the strength and durability of low-cost school furniture constructed at the cottage industry level using small-diameter timber which is especially important in developing countries.

d. Source of Federal Funds: McIntyre-Stennis

d. Scope of Impact: Global

Key Theme: New Uses for Agricultural Products (1)

d. Description: Research on methods to moderate starch digestion rates in processed foods has resulted in two potentially useful findings. First, a process was developed using controlled partial digestion with enzymes followed by spray-drying to produce a range of slowly digesting starches (SDS) with fairly good rheological properties. Molecular analysis of the SDS samples showed relatively low molecular weight, and a higher than normal proportion of debranched long glucan chains, as well as a higher degree of crystallinity, that increased with lower digestion rates. Second, based on work done on the basis of the slow digesting characteristic of cooked sorghum flour foods, a protein-starch interaction was found that appears to account for its slow starch digestion property. Moreover, it was found how to create similar protein occurrences in other cereal flours that accordingly negatively affected starch digestion rate. Slowly digesting starches, which are also low glycemic response starches, are an increasingly relevant research area due to growing evidence of the cause-effect relationship between high glycemic response foods and diabetes, pre-diabetic condition, and possibly obesity.

d. Impact: Finding methods to moderate starch digestion rates in whole and processed foods could have a sizable impact on the pressing public health problems with diabetes, pre-diabetic conditions, and even obesity. Our studies have revealed at least two ways of slowing starch digestion rates in either isolated starch preparations or in formulated foods. This work has also shown how sorghum-based foods can be made more digestible for vulnerable target populations in Africa and Asia.

d. Source of Federal Funds: Hatch

d. Scope of Impact: Global

GOAL 2: SAFE AND SECURE FOOD AND FIBER SYSTEM

Overview: Food safety, and more recently food biosecurity, present considerable public health and economic risks to the food industry and to consumers. The Centers for Disease Control and Prevention (CDC) estimates that 76 million cases of food-borne illness, 325,000 hospitalizations, 5500 deaths, and costs of $7.7-$23 billion occur each year in the United States. These represent non-intentional presence of food-borne hazards only. Since September 11, 2001, the presence of intentionally (bioterrorism) added hazards have also become very important. Prevention of food-borne illnesses from both intentional and non-intentional hazards is enhanced through

effective research and extension programs that focus on detection, protection and prevention strategies, recovery efforts, and education that emphasizes safe food processing, handling, and packaging.

Successes:

- Use of chlorine dioxide gas for intervention and protection against a *Bacillus anthrasis* spore surrogate that could be used as a preventative measure against biosecurity threats
- Developed specific pathogen detection system platforms, using a multi-discipline research team approach, for *Listeria monocytogenes* that are rapid, accurate, and can be applied for ready-to-eat meat products
- Detection of *Fusarium* species of mold in grains and foods by ELISA and PCR
- Development and study of low-cost, rapid-testing methods for measuring total PCBs and mercury in fish tissue
- Development of a magnetic resonance system to evaluate quality of selected fruit and vegetable products
- Establishing techniques for predicting water holding capacity of fresh pork products as an important measurement of pork quality
- Development and evaluation of a 2-hour retail food safety training program based on research-based food handling practices

Benefits:

- The development of more accurate and more rapid bacterial pathogen detection methods, for *Listeria monocytogenes* and other food-borne pathogens, will allow food processors and food regulatory agencies to identify potential problems more quickly, thus reducing the risk of food contamination and food-borne illness.
- The development of detection systems for molds, especially for mycotoxin-producing molds, that that are more accurate and more rapid, will allow food processors and food regulatory agencies to identify potential food safety and food quality problems more quickly. This, in turn, will help reduce the risk of food contamination and food-borne illness as well as strengthen food quality.
- The development of a rapid assay for PCB's in fish tissues will help states as they determine and issue fish advisories and warnings for consumers.
- Development of water holding capacity in fresh pork tissue will improve quality prediction and methods development for improve water holding capacity.
- The use of a magnetic resonance system to scan fruit and vegetables products would reduce loss, increase yield, improve fruit quality and lead to greater customer satisfaction and increased competitiveness in global markets.

State Assessment of Accomplishments:

Purdue University engages itself to meet national food safety and quality goals by establishing multi-disciplinary teams from several departments and schools on campus. A good example of such multi-disciplinary efforts for food-borne pathogens detection is the Center for Food Safety Engineering at Purdue University. Currently, 27 faculty and staff, encompassing five different schools and 14 different departments, collaborate in the Center. Considerable efforts are also placed on integrating research and extension efforts to complex problems and communicate the efforts to important stakeholders in the food processing and retailing industry.

Key Theme: Food Security (1)

a. *Description:* Chlorine dioxide gas has been used as a disinfectant or sanitizer for over 20 years in the medical sterilization field. In recent years, the application of chlorine dioxide gas for the decontamination of food and food-contact surfaces has been extensively investigated at Purdue University. There is very limited information published in the refereed scientific literature concerning the use of chlorine dioxide gas to decontaminate a large building or different surfaces in the contaminated area, or its efficacy to

reduce biological threat agents (including *Bacillus anthracis*). The efficacy of chlorine dioxide gas for the decontamination of *Bacillus thuringiensis* spores on paper, wood, epoxy, and plastic surfaces was investigated. Spores representing approximately a 6 log cfu/surface inoculation level were treated with 5, 10, 15, 20, 25, or 30 mg/L chlorine dioxide gas for 12 hours under 85-92 percent relative humidity and at 22 +/- 1C. Under the tested treatment conditions, the highest population of surviving spores was found on the paper surface and the lowest was on the plastic surface. The 5 mg/L chlorine dioxide gas treatment inactivated 2.5, 3.6, 4.0, and 4.9 log spores/surface on paper, wood, epoxy, and plastic surfaces, respectively. A greater than 5 log reduction of spores on each surface were achieved after 15 mg/L chlorine dioxide gas treatment. The minimum chlorine dioxide gas concentration to completely inactivate the inoculated spores was 30 mg/L for paper and wood surfaces, 25 mg/L for epoxy surfaces, and 20 mg/L for plastic surfaces. The results in this study may be useful in providing insight into parameters for effective decontamination procedures for *Bacillus* spores.

. *Impact:* Food biosecurity has become an increasing concern. Chlorine dioxide, in the gaseous form, provides a very strong antimicrobial against a wide variety of food products and in different food systems. This study has shown its effectiveness against a surrogate to *Bacillus anthraces* (causative organisms in anthrax). When distribution systems and chlorine dioxide gas concentrations are optimized, this should provide a significant weapon against potential biosecurity threats.

. *Source of Federal Funding:* Hatch, NRI

. *Scope of Impact:* National

Key Theme: Food Pathogen Protection (1)

d. Description: There is an imminent need for improved systems for detection of microbial and chemical contamination in foods. Current available detection systems are neither sensitive nor accurate enough, are costly, involve many days for contaminant identification, and are not easily usable for the industry or regulatory agencies. Our approach has combined engineering technologies and food safety expertise to find solutions to these problems. The Center for Food Safety Engineering was established to develop better methods for hazard detection and better ways to control hazards in our food system. Research teams involve five different schools including agriculture, consumer and family sciences, engineering, science, and veterinary sciences. Faculty teams are working on methods to detect pathogenic bacteria, molds and seafood toxins, plus bioluminescence techniques that use infrared sensors. Biosensors are being developed to detect *Listeria monocytogenes* in ready-to-eat processed meat systems. This team has improved sample preparation procedures and optimized a detection-based platform.

d. Impact: The development of bacterial pathogen detection methods that are more accurate and more rapid, will allow food processors and food regulatory agencies to identify potential problems more quickly. This technology could also be easily applied for detecting potential biosecurity threats, which would help in response and recovery efforts.

d. Source of Federal Funding: Hatch, ARS

d. Scope of Impact: National

Key Theme: Food-borne Pathogen Protection (2)

a. *Description:* Research has focused on the development of immunocapture methods for *Fusarium graminearum* and *Fusarium verticillioides.* Three different methods of immunocapture were studied, namely magnetic and nonmagnetic beads, microcentrifuge tubes and microtiter plates. The magnetic beads were not successful in binding the antibody needed for immunocapturing *F. graminearum* and *F. verticillioides*. The nonmagnetic beads based on protein A were able to bind up to 15.0 milligrams of antibody per milliliter of beads and successful immunocaptured both *F. graminearum* and *F. verticillioides*. The second method used a microcentrifuge tube to which the antibody was conjugated. Although the antibody was conjugated to the surface of the tube, the amount was too small to capture mycelial fragments, microconidia, or macroconidia from either *F. graminearum* or *F. verticillioides*. The third method used a 96 well microtiter plate to immobilize the antibodies for the immunocapture of *F. graminearum* and *F. verticillioides*. *F. graminearum* was immuno-captured and confirmed by positive PCR results for the Tri6 gene. The 96 well microtiter plate worked best for the immunocapture because a large number of samples could be prepared easily on one plate, the method was simple to do, and the sample set-up was similar to that used with the real-time PCR assay.

b. *Impact:* The ability to rapidly get molds out of grains and foods will be important for rapid method development. Immunocapture will be one way to easily and rapidly pull *Fusarium* species away from the food for easy identification and enumeration. A polynmerase chain reaction (PCR) was developed and will be combined with the immunocapture for the rapid detection of *Fusarium* species that produce mycotoxins. This should help the grain and food industries quickly determine if these molds are present and, thereby, allow them to prevent their growth and production of mycotoxins.

c. *Source of Federal Funding:* Hatch, ARS

d. *Scope of Impact:* Multi-State

Key Theme: Foodborne Pathogen Protection (3)

a. *Description:* Antibodies are critical for immunosensor applications. One study used a *L. monocytogenes*-reactive monoclonal antibody (MAb-C11E9) and polyclonal antibodies for biosensor assays. These antibodies were characterized in detail to determine their reactivity spectrum with strains of *L. monocytogenes* and *L. innocua* (a nonpathogenic species). About 88% of *L. monocytogenes* strains showed strong reactions with C11E9 while only 23% of *L. innocua* gave equivalent results. This antibody was used in a resonant mirror immunosensor and the antibody was able to detect surface protein extracts from L. *monocytogenes* and *L. innocua* and showed no reaction with other *Listeria* species. In the fiber optic sensor, rabbit polyclonal antibody was used to capture bacteria on the fiber wave-guide and the fluorescent-labeled C11E9 was used to detect bacteria. Using this setup, the sensitivity limit of this sensor was determined to be 1000 cells/ml. This sensor could detect *L. monocytogenes* in the presence of other *Listeria* species, or other common food contaminants (*Enterococcus faecalis, Escherichia coli, Salmonella typhimurium*). Furthermore, this sensor was able to detect *L. monocytogenes* from naturally contaminated or spiked hotdog at cell concentrations of 10, 100 or 1000 cfu/ml after 20 h of enrichment.

b. *Impact:* Fiber optic sensor shows promise in detecting low levels of *L. monocytogenes* from spiked hotdog samples after 20 hour of enrichment. This method would allow early and sensitive detection of *L. monocytogenes* from processed products thus reducing holding time for processed products and prevent

potential food-borne *Listeria* infection. Efficacy of this sensor to detect *L. monocytogenes* from other meat products is currently under investigation.

e. Source of Federal Funding: Hatch, ARS

e. Scope of Impact: National

Key Theme: Food-borne Pathogen Protection (4)

d. Description: Persistent organic pollutants, like PCBs, and heavy metals, like mercury, continue to pose a health risk to consumers of sportfish and commercial fish as demonstrated by fish consumption advisories issued in 43 states and federal advisories for sensitive populations. Limitations that occur when developing advisories are related to the cost for collecting and analyzing sportfish. Lower-cost rapid ELISA test for measuring total PCB in fish tissue was developed and applied to the measurement of total PCB in 26 omega-3 fatty acid dietary supplements. Also examined was a new analytical instrument that permits rapid measurement of mercury in fish tissue. Analysis by this instrument was validated using previously analyzed recreationally-caught fish tissue samples. In addition, mercury residues in canned fish products and in retail restaurant fish sandwiches were measured.

d. Impact: These assays will help develop fish consumption advisories for recreationally-caught fish and will help regulatory agencies survey commercial fish products. In addition, the methods were used to measure PCBs and mercury in fish so that sensitive populations, i.e., pregnant or nursing women and young children, can be provided with the necessary information to make an informed decision concerning their fish consumption.

d. Source of Federal Funding: Hatch

d. Scope of Impact: Multi-State

Key Theme: Food Pathogen Protection (5)

d. Description: Survival and growth of *E. coli* O157:H7 (EC) and *L. monocytogenes* (LM) on strawberry surfaces after 7-days at 4^{o}C, in strawberry juice, and in acidified media at different pH levels and storage temperatures, were investigated. Strawberries were spot-inoculated with 8 log cfu/strawberry of each pathogen, dried for 2 hours or stored for 1 or 7 days at 4 ^{o}C, and examined for bacterial survival. Sterile strawberry juice (pH 3.6) and the acidified media containing strawberry juice (pH 3.4-6.8) were inoculated with 6.7 log cfu/ml EC and 7.3 log cfu/ml LM, respectively, incubated at 4 and 37 ^{o}C, and enumerated after 2 hours, 1 or 3 days. Bacteria were recovered using surface plating on sorbital MacConkey agar for EC and modified Oxford agar for LM. Membrane-transferring plating with tryptic soy agar combined with the selective medium was used to recover injured cells. As storage time increased, bacterial populations on strawberries decreased and the level of injured cells increased. After 7 days storage, a log reduction of 1.0 ±0.2 and 2.7±0.3 was observed for EC and LM, respectively. EC survived well at 4 ^{o}C at pH 3.4-6.8, but the percentage of injured cells increased with increasing pH. Injury appeared to be acid-induced and occurred within 2 hours of storage. EC was inactivated at pH <3.6 at 37 ^{o}C, but could grow at pH 4.7 at 37 ^{o}C. LM was quickly (<2 hours) injured at pH <4.7 at 4 ^{o}C and inactivated as storage time increased. LM survived well at pH 6.8 at 4 ^{o}C, and grew well at 37 ^{o}C.

d. Impact: The results of this research will result in a safer product with longer shelf-life. This provides benefits to the public health sector and economically to the produce industry.

d. *Source of Federal Funding:* Hatch, NRI

d. *Scope of Impact:* Multi-State

Key Theme: Food Quality (1)

d. *Description:* A conveyor system was developed and tested that allows CPMG T2 tests to be conducted on fruits and vegetables as they move through the magnet of a low-field (5.35 MHz) H-MR sensor. When samples were held in position at the center of the sensor coil for at least 15 seconds (0 mm/s), the T2 curves of healthy apples and apples with internal browning were distinctly different. In tests conducted on 16 apples (9 healthy, 7 with internal browning), the classification error was 12.5% at 0 mm/s. Classification errors at 50, 150, and 250 mm/s were 12.5%, 31.25%, and 25.0%, respectively. In addition to tests on apples, tests were initiated on low field H-MR sensing of the quality of tomatoes for canning. Preliminary analysis indicated that the T2 of the processing tomatoes decreased as the tomatoes matured. The firmness of canned, diced tomatoes sorted on the basis of color and T2 value will be measured to determine the relationship between tomato T2 value or color and the diced tomato firmness.

d. *Impact:* The goal of the H-MR sensor work on apples is to adapt the sensor for on-line detection of internal browning and other internal defects of fruits and vegetables. On-line H-MR sensing of apples would permit apple lots containing unacceptable levels of internal defects to be sorted so that defective fruit could be removed. Losses would be reduced and fruit quality improved leading to greater customer satisfaction and increased competitiveness in global markets. Processors could use the results of the grading to direct each truckload to the end use for which it is best suited either sauce or canning. This would increase the processors yield (pounds of canned tomato per ton of tomatoes processed) and provide an incentive for growers to deliver tomatoes at the optimum stage of maturity.

d. *Source of Federal Funding:* Hatch

d. *Scope of Impact*: Multi-State

Key Theme: Food Quality (2)

d. *Description:* Techniques for predicting the waterholding capacity of fresh pork cuts soon after the harvest process begins would allow the pork chain to respond effectively in eliminating or reducing the incidence of poor quality pork. Two new research techniques for following the progression of change in waterholding capacity during the first 24 hours post-exsanguination were developed. One method involved the insertion of cotton implants that are absorbent and detect the release of water from cells into selected muscles of the carcass. The other method involved removal of muscle samples from the carcass at given time intervals for centrifugation to determine water release. Results suggest that each technique provides different information regarding moisture release because of the difference in force applied. These techniques were used to establish the relationship of water release at early post exsanguination time intervals to the ultimate drip loss observed at 24 to 48 hours post-exsanguination. Utilization of the cotton implants were easily controlled and proved valuable in gaining an understanding of water release from pork muscle at the various stages of conversion of muscle to meat and may be more helpful in elucidating differences in the development of drip loss problems than the centrifugation technique. NIR spectroscopy was demonstrated to measure drip loss at 24hr postmortem with a regression coefficient in the 0.7 range across treatments and genotypes. Results from the use of Near Infrared spectroscopy on 65 pork carcasses show that the correlation between spectral readings taken 30 minutes post-exsanguination over a 30 second time interval is 0.77. This result compares favorably with previous observations by the principal investigator in a study conducted in Denmark with a completely different and more uniform genetic population where the correlation was 0.84.

b. Impact: The availability of more sophisticated NIR instruments, along with the improved design of new sensing probes provides greater potential for the procedures developed and patented during these studies to move to on-line application for the prediction of water holding capacity in fresh pork. This project has laid the groundwork for eventual commercialization of this technology to predict the moisture retaining capabilities of fresh pork.

c. Source of Federal Funds: Hatch

d. Scope of Impact: Multi-State

Key Theme: Food Handling (1)

a. Description: The majority of reported food-borne illnesses have been attributed to the end of the food production chain through retail food establishments (restaurants, institutions, supermarkets, convenience stores, etc). One of the important keys to prevent food-borne illness is through effective education and training for retail food establishment employees. "Food Safety Day" is a 2-hour retail food safety program intended for retail food workers and managers. The project goal was to develop a curriculum that emphasized safe food handling practices that focuses on the most significant food handling problems including time and temperature abuse, cross contamination, poor personal hygiene and sanitation. Indiana employs over 165,000 people in nearly 18,000 retail food establishments, creating a significant training need for our state that this curriculum is fulfilling. The retail food industry nationwide employs over 1.2 million people. The program has four learning modules: Understanding Food-borne Illness, Good Personal Hygiene, Preventing Cross-contamination, and Avoiding Temperature Abuse. The instructor kit contains hands-on demonstrations for each module packaged with 58 slides along with an instructor and a student guide. The initial audience for this program is health department personnel and Extension Educators in a train-the-trainer program. The ultimate audience, delivered by trained trainers, for this program is retail food managers and retail food workers. The curriculum is available in Spanish and English as a hard copy curriculum (slides or color overhead transparencies) and can be downloaded from the World Wide Web. (http://www.foodsci.purdue.edu/publications/foodsafetyday/)

b. Impact: Over 25,000 people have been educated using this program since its development in 1996. The program is offered at least monthly throughout Indiana. Last year approximately 5000 people attended food safety day. Pre- and post-test data indicate that participants have leaned better food safety handling practices related to time and temperature control, good personal hygiene, and cross contamination control. The largest positive change has been better personal hygiene practices. The program has grown from a state program to a national and international program. Food Safety Day has been used in 19 other states and is used extensively in Central and South America. Maryland has recently incorporated Food Safety Day as part of their mandatory retail food handler training requirements.

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

d. Scope of Impact: Global

Key Theme: Food Handling (2)

a. Description: Many states, including Indiana, have implemented mandatory food safety training and/or certification examination programs for the retail food industry. Indiana requires at least one retail food manger from each retail food retail establishment be certified in retail food safety and must pass a nationally recognized exam. Three programs are offered in Indiana to address these needs. The *Essentials of Food Safety and Sanitation* and *SuperSafeMark* programs were each developed as nationally

recognized curriculums and certification program for retail food handlers. The *Essentials of Food Safety and Sanitation* program is intended mainly for supermarkets and foodservice, and the *SuperSafeMark* program has been customized for supermarket and convenience store operations. Each program is designed as an 8-hour or 16-hour program for retail food managers and is linked with a retail food certification exam. The targeted audience includes retail food managers and retail food workers. The program is also offered to corporate trainers and academic trainers that serve the retail food industry.

d. Impact: Within Indiana, over 3500 people are certified each year using these programs. Program participation is expected to rise significantly prior to January 2005 when a mandatory certification rule comes into effect. This retail food safety curriculum provides an important training need for retail food managers. The training should reduce the risk and likelihood of food-borne illness and improve food-handling practices in retail food establishments.

d. Source of Federal Funding: Hatch, Smith-Lever

d. Scope of Impact: State

GOAL 3. A HEALTHY, WELL-NOURISHED POPULATION

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

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

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

Vitamin D, also a factor in adequate calcium absorption, has many other roles in the human body. Normal cells have very tight regulatory mechanisms for growth control and programmed cell death. Cancer is a state where cell growth and programmed death has been changed dramatically from normal. Studies have shown that the active form of Vitamin D (1, 25$(OH)_2$D) inhibits cell death in normal cells, but not in cancer transformed cells. Understanding the mechanisms of how Vitamin D regulates cell growth and death could ultimately lead to dietary recommendations to reduce the risk of cancer.

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

Reduction in caloric intake: Carbohydrate research is also directed at the identification of alternative sweeteners and fat substitutes in foods to reduce caloric content. Low calorie gums (guar and methylcellulose) were used in popular nutritional drinks to control viscosity and ultimately food rheology. Raftiline, a fructose polysaccharide was used as a replacement for hydrogenated fat in a pie crust. The crust was more puffy and tough than controls with regular hydrogenated fat. Studies continue to determine the maximum amount of Raftiline that can replace fat and still produce an acceptable product.

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

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

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

Successes:

- Calcium retention in adolescent boys is higher than in adolescent girls when fed equal amounts of calcium in foods.
- Cereal starch has been modified through controlled digestion to produce slowly digested starch with desirable food rheological properties.

Benefits:

- Vitamin D may hold promise in the regulation of cell growth and programmed death.
- Bio-engineered tomatoes have been produced with increased lycopene levels and very positive juice quality

State Assessment of Accomplishments:

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

Key Theme: Human Health (1)

d. *Description:* The interest in dietary components, such as vitamin D, in the prevention of cancer has recently increased as the importance of this compound in the regulation of cell growth and death has become recognized. Normal cells have tight regulatory mechanisms underlying growth control and appropriate stimulation of programmed cell death or apoptosis. Cancer is characterized by unregulated growth of cells which are also resistant to cell death. In order to develop recommendations for preventive or therapeutic measures, it is important to understand the regulatory mechanisms of both growth and apoptosis. The active metabolite of Vitamin D inhibits apoptosis in normal cells, but does not have the same inhibitory effect on cells containing a mutated gene commonly found in cancers. Research in other models for prostate and breast cancer are now being conducted to identify how Vitamin D regulates cell growth and death at various stages of cancer progression.

d. *Impact:* In 2003, 552,000 Americans were expected to die of cancer. This is the second leading cause of death in the United States. Understanding how growth and death decisions by cells are regulated will lead to improved dietary recommendations to prevent or cure cancers and lead to a reduction in death from this disease.

d. *Source of Federal Fund:* Hatch, NIH

d. *Scope of Impact:* Multi-state

Key Theme: Human Health (2)

d. *Description:* Bioavailability and metabolism of calcium in adolescent boys aged 13-15 was measured. Boys were studied twice during two controlled feeding periods of three weeks each using a randomized order, crossover design on diets ranging in calcium intake from 800-2300 mg/day. Calcium retention at all intakes was higher in boys than girls.

d. *Impact:* Boys develop a larger skeleton than girls, but it was not known whether calcium requirements are higher or if boys use calcium more efficiently than girls. Studies conducted to determine the relationship between calcium intake and calcium retention in boys show that calcium required for boys is not higher than girls, but that boys utilize calcium more efficiently.

d. *Source of Federal Funds:* Hatch, NIH

d. *Scope of Impact:* Multi-state

Key Theme: Human Nutrition (1)

d. *Description:* Earlier studies demonstrated the ability of psyllium to lower serum cholesterol in experimental animals and in humans. Studies show observed changes in the abundance of mRNA for enzymes involved in cholesterol and bile acid synthesis as well as the active transport reabsorption of bile acids from the ileum. To study the impact of psyllium on hepatic gene expression Wistar rats were fed semi-purified diets containing 10% dietary fiber from cellulose (control) or psyllium for 21 days. Animals were killed and total liver RNA samples were subjected to microarray analysis. mRNA levels of genes involved in cholesterol synthesis and metabolism were significantly higher in the psyllium group. Northern blot analysis was carried out on four mRNAs and only HMG CoA synthase was significantly increased (32 fold). These changes suggest additional mechanisms for the effects of psyllium on cholesterol metabolism that need to be explored.

d. Impact: Dietary fiber has been epidemiologically linked to a number of chronic diseases. Understanding the mechanism of its effect on disease is critical to any dietary guidance. Promise in the area of dietary fiber and the enzymes that are responsible for cholesterol synthesis will be followed.

d. Source of Federal Funds: Hatch, NIH

d. Scope of Impact: Multi-state

GOAL 4: GREATER HARMONY BETWEEN AGRICULTURE AND THE ENVIRONMENT

Overview: Protection of our natural resources is critical to Indiana's agricultural sector and rural population, and is an important area of research at Purdue University. The impact of research conducted under Goal 4 is supporting producers and citizens of Indian in meeting environmental quality standards imposed under both state and federal law.

Fertilizers and Ag Chemicals: Purdue researchers continue to work towards an understanding of the interaction between agricultural practices and surface water quality in an effort to minimize negative impacts from 921, 450, and 871 million pounds of N, P, and K, respectively, applied annually to Indiana crops. Purdue scientists are also working to reduce the negative impacts the 21,699,000 pounds of herbicide and 800,000 pounds of insecticide applied to the same crop base annually. The state's 303(d) list has reported 428 impaired water bodies in Indiana. Since many of these impairments can be traced to agricultural practices, Purdue Extension professionals are delivering management tools and strategies that can be used at the individual farm level to help meet impending Total Maximum Daily Loads without undue hardship on producers.

Animal Waste: Purdue researchers are providing methods for handling and reducing nutrient content, primarily phosphorus, of the approximately 14 million tons of solid and 1.6 billion gallons of liquid waste produced annually by livestock in the state's 38,000 large production facilities. Purdue University is a national leader in helping confined feeding operators understand and address air quality issues. Purdue researchers are making significant strides at using economical diet formulations that reduce the pollution potential of manures while maintaining animal growth and health.

Septic Systems: Nearly 25% of the state's 800,000 home septic systems are malfunctioning and need to be replaced, and most Indiana soils are not suitable for traditional septic systems. Purdue scientists are providing technologies and management approaches that better address the issue of septic system placement in Indiana soils.

Overall, results from Goal 4 have provided approaches, practices, software, and management systems that enhance and sustain our resource base while maintaining the productive capacity of the land and employment opportunities for our rural population.

Successes:

- Developed a manure handing technology for use in commercial high-rise caged pullet operations that reduces operating costs and environmental nuisance concerns without the use of more pesticides.
- Demonstrated the effectiveness of computer based septic system accounting system using GIS that compares septic system permit records to soil survey data.
- Demonstrated that *Scirpus* and *Carex* are excellent plants for accelerated dewatering of contaminated sediments.
- Developed methods that improved our understanding of the genetic and biochemical basis of macro, micro and trace element accumulation in plants which can become a means of phytoremediation.

- Demonstrated arsenic (As) in fly ash from power plants is primarily As(V), which is highly sorbed; As(III) is also observed in fly ash and is much more mobile than As(V). As(III) mobility is further enhanced in the presence of high sulfate concentrations typical of leachate from many ashes.
- Demonstrated a method to determine residual toxicity in recycled biosolids using tests that include earthworm mortality, growth, and reproduction; seedling germination and root elongation; microbial respiration; and nematode mortality/reproduction.
- Helped the State Department of Transportation meet Rule 13 Stormwater Management regulations by using a new GIS system that identifies sensitive river locations. Attention is given to the location of the bridges and highway department facilities in order to protect high-quality surface waters.
- Provided a quantitative foundation for more efficient state recommendations on N management for corn which can reduce nitrate loading of tile drainage water.
- Developed a new computer model that offers a reliable, rapid and inexpensive way to predict the movement of water and chemicals in the soil/groundwater system.
- Developed a complete revision of the university K recommendations to include soil- and crop-specific interpretation of soil test results and guidance on how to mange K fertility to maximize yields in both low and high yielding environments.

Benefits:

- Alternative mound septic systems last longer in problematic soils than conventional trench septic systems.
- Use of phytase in swine diets can reduce phosphorous content in manure and reduce land requirements for manure application.
- Riparian Best Management Practices can improve stream habitat quality and macroinvertebrate communities downstream.
- Carbon sequestration could offer farmers the opportunity to earn $10-$30 per acre.
- Animal antibiotics were not found to leach through the soil or tile lines.
- No-till corn represents about 1/5 the Indiana acreage.
- Habitat restoration such as grassland and wetlands can repair damaged ecosystems.

State Assessment of Accomplishments:

The research initiatives under this goal are addressing Indiana priorities in soil, water and air quality conservation and management. Researchers have identified and evaluated technologies and tactics that can be used by producers to reduce negative environmental impacts. Producers have been provided with alternatives for manure management, reduction in pesticide use, and better decision making tools for improving the sustainability of their operations. Purdue Extension professionals work closely with state government agencies such as the Indiana Department of Natural Resources and Indiana Department of Environmental Management as well as private groups such as the Nature Conservancy. Others work with Federal agencies such as the Natural Resource and Conservation Service and the Environmental Protection Agency.

Key Theme: Managing Change in Agriculture (1)

a. *Description*: Evaluation of how red-shouldered hawks and red-tailed hawks used woodlands in landscapes with different degrees of fragmentation and agriculture continued. It has been hypothesized that the generalist red-tailed hawk displaces the more woodland specialist red-shouldered hawk as fragmentation increases. Nesting success for both species for a total of 75 nests on three areas with decreasing percentage woodland indicate no difference in success or numbers of young produced for any species/study area combination, but there was a significant difference in nest area for the two species, with red-tailed hawks choosing sites with less total woodland and more woodland patches (i.e., more fragmented) and red-shouldered hawks choosing more extensively wooded areas with more wetlands. In

general, red-shouldered hawks consumed more snakes, amphibians, and inverterbrates and red-tailed hawks more mammals. The food niches overlaps (both Morista's and Pianka's indices) were greatest in the least fragmented site, indicating potential competition when both species were using approximately the same landscape. In the moderately fragmented site, the two species partitioned the study area with red-tailed hawks using more fragmented upland areas and red-shouldered hawks the more continuously forested bottomland; food selection mirrored this segregation and overlapped less. Row-crop fields are poor foraging areas and typically contain relatively few perches from which to hunt. Thus, hawks must fly farther to reach more distant foraging patches. Although such birds had nest food delivery rates similar to birds in less agriculturally-dominated landscapes, they had to devote more time to foraging and were at the nest (guarding) significantly less. Correspondingly, these red-tails in highly fragmented landscapes had lower nesting success than those in areas with more abundant woodlands. These factors (low percentage of time at nest/low nest success) are likely related, but it is probable that predator densities vary among landscapes as well.

d. Impact: Agricultural land use impacts the finances of the farmer. It also impacts animal communities. How various land use components fit together on the landscape, without necessarily changing proportions of each component, impact even animal species, such as the red-tailed hawk, that have adapted to agarian environments. Planning at the farm level, rather than the field level, will help to retain the animal community as well as the farm's profitability.

d. Source of Federal Funds: Hatch

d. Scope of Impact: Eastern United States

Key Theme: Agricultural Waste Management (1)

d. Description: Researchers at Purdue University continue to expand the usefulness of the Manure Management Planner (MMP). This program is widely used to generate comprehensive nutrient management plans (CNMP) for crop and livestock producers.

d. Impact: MMP is the only nutrient management software supported nationally by NRCS and EPA for meeting their respective program requirements. The enhanced MMP software is being used to create nutrient management plans for crop and livestock producers in 22 states (AL, DE, GA, IN, IL, IA, KS, MA, MI, MN, MO, MS, NE, ND, NM, OH, OK, PA, SD, TN, UT and WI), and 10 more states will be added in 2004. Thousands of hours of producers time to generate CNMPs have been saved.

d. Source of Federal Funds: Hatch, NRCS, Smith-Lever

d. Scope of Impact: Multi-state

Key Theme: Agricultural Waste Management (2)

d. Description: Purdue University researchers are continuing to reduce the environmental impacts of animal agriculture through diet modification. One group has investigated the use of low phytic acid (LPA) corn and soybeans in feed formulations for pigs. Such grains are genetically enhanced and can be combined with feed additives, such a phytase, to improve performance while minimizing nutrient levels in wastes. Another research project is looking at the addition of copper from a variety of sources on utilization of phytate phosphorous in broiler chickens. Copper is often added to broiler diets for its anti-microbial and growth promoting properties, despite the potential problems it can cause by chelating phytate phosphorous.

b. *Impact:* Diets containing LPA grain plus phytase can significantly reduce phosphorus in swine manure over using phytase alone (43% reduction LPA + phytase vs. ≤ 18% reduction LPA grain or phytase alone). Phosphorous reduction can be achieved without adversely affecting animal growth and productivity. Additionally, researchers found that feeding poultry pharmacological doses of copper sulfate can greatly reduce phosphorous utilization. Copper should be supplemented as copper chloride or copper lysinate to help ensure proper phosphorous utilization and minimize environmental impacts of poultry operations. These are significant steps toward implementing economically viable methods for significantly reducing land requirements for manure application.

c. *Source of Federal Fund:* Hatch, IFAFS

d. *Scope of Impact:* Multi-state

Key Theme: Air Quality (1)

a. *Description*: Ozone is formed as a product of fossil fuel combustion and its actual impact on crop production in Indiana and other urbanizing locations is largely unknown. Many controlled chamber (greenhouse) studies have shown ozone and sulfur dioxide to have deleterious effects on soybean yield. To determine if there is evidence to support this assertion about yield losses associated with the presence of ground level ozone, a study was conducted using existing county-based soybean yield and EPA CASTNet ozone concentration data. A correlation model of soybean crop yields between 1988 and 2000 and monthly and seasonal air temperature, precipitation, solar radiation, ozone concentrations and sulfur dioxide concentrations at 20 locations between 45 and 34 degrees north latitude was developed.

b. *Impact:* Decreases in soybean yield were correlated with mean seasonal 7-h ozone concentrations in 69% of all locations evaluated and 100% of the locations below 42 degrees north latitude. The yield decline was significant at ozone levels above 33 kg/ha per ppb (nL/L) seasonal mean 7-h ozone for locations between 42 and 38 degrees north latitude, with 31% of the yield variability explained by the mean 7-h ozone concentrations in July. These findings clearly demonstrate the need to consider the impact of urban source ozone and sulfur compounds pollution on the agricultural community. This suggests that plant breeders should now be considering including the selection of soybean cultivars with increased pollution resistance in an effort to offset some of this yield declines.

c. *Source of Federal Funds*: Hatch.

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

Key Theme: Water Quality (1)

a. *Description*: The impact of stream bank best management practices (BMPs) on fish community composition and related habitat variables along a gradient of land uses from agricultural to urban were evaluated in a two-year study. These BMP are standard practices such as vegetative filter strips that can be of use in both agricultural and urban settings. A significant correlation between impervious area in urban areas, (as little as 10%), channel morphological change, reduced habitat quality, and the loss of sensitive members of the fish community was discovered. Sensitive species requiring good quality habitats and stable substrates become less common as urbanization proceeds in a Midwestern watershed. The changes appear to be related to increased runoff and more unstable stream flow and are not simply water pollution. In particular, species that rely on a stable substrate for feeding and reproduction (darters, sculpins, and several minnow species) were absent from urban streams.

b. *Impact:* The beneficial effects of different riparian BMPs for Midwest stream ecology were documented and provide clear support for current cost-share programs used to encourage the use of conservation methods. The Conservation Reserve Program (CRP) provides technical and financial assistance to farmers to address soil, water, and related natural resource concerns often with the use of BMPs. Where riparian BMPs have been implemented, significant improvements in stream habitat quality and stream macroinvertebrate communities downstream were found. This is one of only a very few studies that have directly measured the impact of riparian BMPs on streams in the Midwest.

c. S*ource of Federal Funds:* Hatch, NRCS

d. *Scope of Impact:* Multi-state

Key Theme: Water Quality (2)

a. *Description:* Research is characterizing C-sequestration and related co-benefits (water quality improvements) as well as costs to the producers. The goal is to improve water quality management in rural and mixed-use watersheds, and to provide benchmark information for state agencies (NRCS, Indiana Department of Environmental Management, Indiana Farm Bureau Association) that are exploring the feasibility of C monitoring programs. Since C sequestration is a slow process, initially the study has concentrated on N management and drainage. The Purdue University Water Quality Field Station, Purdue Agricultural Centers and local mixed-use watersheds are being used to quantify the effect of crop rotation, source and rate of nitrogen, and drainage intensity on rates of C-sequestration and loss via subsurface tile drains. Field experiments have been implemented to compare the efficacy of variable N fertilizer management on C retention in soil.

b. *Impact* : The Natural Resources and Conservation Service suggests that in the near future farmers may be able to earn credits for storing carbon in their soils and this would provide an additional source of income for the farming community ($10 to $30/acre). A quantitative foundation for more efficient state recommendations on N management for corn as related to improved retention of C in soil is being formulated from this work. This research is improving our understanding of the active C/N pools as influenced by management, thereby improving our ability to manage N and C.

c. S*ource of Federal Funds:* Hatch, USDA-CSREES Special Grant

d. *Scope of Impact:* Multi-state

Key Theme: Water Quality (3)

a. *Description:* Subsurface tile drainage is a common water management practice in agricultural regions with seasonal high water tables. Although subsurface drainage has many benefits (greater infiltration, lower surface runoff, improved crop growth and yield), it also may increase nitrate-N losses through the rootzone and into surface water. An appropriate balance between increasing drainage intensity (narrower spacing) to improve drainage and decreasing drainage intensity to reduce nitrate-N losses needs to be found for different climatic and soil regions. Researchers at Purdue University have completed analyses of nitrate leaching over a 15-year study period containing varying climate and changes in management practices for a site located in southeastern Indiana. The site includes three tile drain spacings (5, 10, and 20 m) managed for 10 years with chisel tillage in monoculture corn (Zea mays L.) and is currently managed under a no-till corn-soybean rotation.

b. *Impact*: A combination of cover crops and reduced fertilizer application can reduce flow-weighted NO_3-N in drainage water from 28 mg L^{-1} to 8 mg L^{-1}. These results show that at least on the low organic matter

soils concentrations of nitrate-N in tile drainage can be reduced to below the drinking water standard of 10ppm. The results are promising as concerns about nitrate contributions to surface waters in the Mississippi River basin and their potential impact on hypoxia in the Gulf of Mexico continue. Therefore, reductions in nitrate loading from tile drainage water can be achieved by implementing better N management practices in continuous corn and corn/soybean production systems. The data suggest that real gains in water quality improvement may also require tile drain flow volume management. The documentation of the strong linkage between yield and nitrate concentration in drainage water in the following winter/spring may permit forecasting of surface water quality problems in rural watersheds from yield records.

c. *Source of Federal Funds*: Hatch

d. *Scope of Impact:* Multi-state

Key Theme: Water Quality (4)

a. *Description:* Veterinary pharmaceutical antibiotics used to improve animal production are excreted in the urine and feces, which are commonly applied to agricultural fields following a holding period in storage lagoons or pits. Several of these antibiotics, e.g., chlortetracycline and oxytetracycline, have been found to be quite persistent in soil and manure systems and have been detected in surface waters. Sorption studies were conducted with the veterinary pharmaceuticals, Tylosin A, Tylosin A aldol, chlortetracycline, oxytetracycline, and tetracycline in several soils representing a wide range in soil properties. Results indicate sorption of the chemicals to soil was significant and was influenced by cation exchange capacity and pH, and in some cases clay type.

b. *Impact:* This work demonstrates that the potential for veterinary pharmaceuticals to leach into groundwater or move through soil to drainage tile lines and then to surface water is limited by sorption of the chemical onto soil. Land application of manure and the subsequent sorption to the soil surface is effective at immobilizing pharmaceutical chemicals contained in the 14 million tons of solid and 1.6 billion gallons of liquid waste produced annually by livestock in the state's 38,000 large production facilities. Studies on tetracylcine, tylosin, and carbadox show that these compounds are highly sorbed to soils, thus their most likely route of entry into water bodies will be through spills, surface runoff, erosion, preferential flow, and facilitated transport and not leaching to tile lines or to ground water.

c. *Source of Federal Funds*: Hatch

d. *Scope of Impact:* Multi-state

Key Theme: Biological Control (1)

a. *Description:* Plant genetic resistance or chemical controls of major soilborne diseases of crops grown in the North Central Region are not generally available. The mechanism of virulence of these pathogens and mechanisms of control through crop rotation and other cultural practices are not well understood. Work at Purdue University has been conducted to isolate and characterize virulence genes in two plant pathogens. These studies will provide insight into how biological control agents influence infections in order to develop more specifically targeted mechanisms of controlling pathogens. In order to understand virulence, a pathogenic *M. grisea* mutant has been identified and characterized. Work is progressing on observing the expression of laccase and Mn peroxidase genes by *M. grisea* under various culture conditions and infection stages.

b. *Impact:* Increasing the availability of Mn through agricultural management practices or soil microbial manipulation can greatly reduce the incidence and severity of take-all of wheat, rice blast, and potato scab; increase yields; and save producers thousands of dollars. This work demonstrates that Mn-oxidation appears to be the causative step in disease formation for many plant pathogens. Both the current and preceding crop in the rotation influence Mn transition states in soil which can influence plant growth and resistance to disease along with the microbial interactions important in establishing biological control. This work is being used to develop new cost effective management practices that minimize economically important diseases.

c. *Source of Federal Funds*: Hatch

d. *Scope of Impact:* Multi-state

Key Theme: Sustainable Agriculture (1)

a. *Description:* Research and extension efforts on strip tillage are forming an essential component of a new conservation planting system for corn in Indiana and surrounding states. Adoption of the no-till system for corn reached a peak of about 25% of the acreage in 1995, it has leveled off at about 20%. Concerns about possible delayed planting and poor plant establishment due to the cooler and moister soils associated with no-till, relative to conventional tillage systems, has been the main impediment to further adoption. Because the only tillage with strip tillage is in the intended row areas for corn (usually planted on 30" centers), strip tillage has combined the best of both tillage alternatives. It preserves from two-thirds to three-quarters of the surface residue cover of no-till, and it permits soil drying and warming in spring to be as fast as it is after fall conventional tillage operations. The failure to use no-till has resulted in continued high costs related to tillage and an increased wind and runoff erosion potential.

b. *Impact*: Research at Purdue has helped fall strip tillage become the fastest growing conservation tillage system (in terms of estimated percentage increase) in the last 5 years. It has been adopted by farmers on both ends of the tillage spectrum; no-till farmers have converted to it in place of continuous no-till, and conventional-till farmers have converted to it to save input costs and reduce soil erosion. Thus, more corn farmers are being reassured that planting dates need not be delayed (as it might be for no-till on poorly drained soils in some springs), and that early corn growth rates and final yields are comparable to those with conventional tillage. Furthermore, the soil savings with strip tillage will preserve long-term productivity.

c. *Source of Federal Funds*: Hatch

d. *Scope of Impact:* Multi-state

Key Theme: Natural Resources Management (1)

a. *Description:* Purdue researchers are conducting long-term studies of avian response to habitat restoration in restored grasslands and wetlands. This study examines the impacts of prescribed burning as a restoration technique in oak-hickory forests, with particular emphasis on breeding birds. Results demonstrated that active restoration systems yield ecological benefits not gained using a passive approach (as suggested by the phrase, "let-nature-take-its-course"). For example, breeding amphibian populations and migratory water birds (ducks and shorebirds) responded much faster to active restoration of former farm fields enrolled in the Wetland Reserve Program administered by the U.S. Department of Agriculture than they do in passive systems.

b. *Impact:* Habitat restoration is a major conservation activity engaged in by private landowners, conservation groups, and state and federal agencies and improvements in efficiencies are critical as approaches to improving the efficiency of restoration have been lacking. This research is providing guidelines that more effectively restore habitats in an ecologically responsible manor. Using an aggressive approach, large areas of grasslands and wetlands in Northwestern Indiana's Conrad Station Preserve (800 acres) have been restored much more quickly by The Nature Conservancy. This work shows that active approaches to habitat restoration will have a more significant impact on the repair of damaged ecosystems than more traditional methods.

d. S*ource of Federal Funds:* McIntire-Stennis

d. *Scope of Impact:* Multi-state

Key Theme: Hazardous Materials (1)

d. *Description:* Substantial progress has been made in uncovering the molecular genetic and biochemical basis of metal hyperaccumulation in the Ni/Zn hyperaccumulator *Thlaspi goesingense* and the Se hyperaccumulator *Astragalus bisulcatus*. It has been discovered that constitutively elevated serine acetyl transferase (SAT) activity plays a key role in the Co, Ni and Zn tolerances observed in *Thlaspi goesingense* and more broadly in 15 Brassicaceae hyperaccumulator species. This elevated SAT activity plays a central role in enhancing the plants ability to resist the oxidative stress imposed by metal via enhanced biosynthesis of glutathione and increased activity of GSH reductase and catalase. To further understand the mechanism of metal hyperaccumulation over 50 different species and ecotypes of Brassicaceae hyperaccumulator are being screened for a plant ideally suited to be developed into a model genetic system. Over expression of selenocysteine methyltransferase (SMT) from the Se hyperaccumulator *A. bisulcatus* in Arabidopsis thaliana appears to confer increased tolerance to selenite and increased accumulation of total Se (Ellis et al., in review). However, SMT over expression does not dramatically effect tolerance or accumulation of selenate. It is hypothesised that for SMT to confer accumulation and tolerance to selenate it will be necessary to enhance both selenate reduction and SMT activity. By studying the genetic basis of metal uptake and accumulation in the non-accumulator, model system, *A. thaliana,* efforts are underway to uncover genes that will be of use in the development of plants suited to phytoremediation. This work has lead to the concept of the ionome - the sum of all the inorganic ions within an organism. The focus is on identifying genes and gene networks responsible for regulating the ionome in *A. thaliana.* To date such studies have involved measurement of the ionome in over 20,000 A. thaliana mutants with both random and defined genetic lesions. The ionomic data generated is assessable to the Plant Biology community via a searchable web-based interface (http://hort.agriculture.purdue.edu/Ionomics/database.asp), and seeds for over 40 mutants showing significant alterations in their shoot ionome have been submitted for distribution to the Arabidopsis Biological Resource Center (ABRC).

d. *Impact:* The research may have a significant impact in the fields of phytoremediation, plant nutrition and human health via improvements in our understanding of the genetic and biochemical basis of macro, micro and trace element accumulation in plants.

d. *Source of Federal Funds:* Hatch, DOE, NSF

d. *Scope of Impact:* Global

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

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

A USDA-funded Agricultural Innovations Center composed of Purdue University researchers and county extension staff is helping farmers develop value-added business proposals. An ethanol plant and a food-grade corn processing plant are currently in the finally planning and construction phases. Other studies are examining the potential for Indiana certified pork, direct marketing and agri-tourism, and community kitchens to help small farmers process produce under sanitary conditions. Also, agricultural economists have developed computer software that helps county government officials determine the fiscal impacts of local commercial, industrial, and residential development. This is very important information for local plan commissions and county commissioners.

Many families are adversely disrupted by the judicial system and must find ways to adjust family life. In other cases, generation of employment is critical to rural family well-being. Purdue researchers and Extension professionals work closely together to develop, deliver, and evaluate programs to enhance rural communities and families' social and economic well-being.

Successes:

- A computer-based GIS models can help local communities estimate the fiscal impact of commercial, industrial, and residential development.
- Research is developing the viability of increasing the income of farm households through on-farm diversification and off-farm employment.

Benefits:

- Personal finance education can result in financial security in later life and help establish family businesses.
- A fiscal impact model for Indiana counties, municipalities, and school corporations allows local decision makers to analyze the tax revenue and budget expenditure impact of residential, commercial, and industrial development in a local community.
- Preschoolers can learn to interact more effectively with children with disabilities.

State Assessment of Accomplishments:

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

Goal 5: Enhanced Economic Opportunity and Quality of Life for Americans

5. A. Improved Quality of Life

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

d. Description: Agriculture and food processing are important sectors in the Indiana economy contributing $2.3 and $2.7 billion to state gross state product, respectively, but account for less than 3 percent of gross state product. As the economic role of production agriculture and food processing changes, rural communities seek strategies to attract new investments and valued-added agricultural activities to sustain local income and employment. Research found that farm land prices are impacted more by the potential of the land for conversion to higher value use than its value in agricultural production. Higher land prices, combined with a new property tax system that has shifted tax liability to agricultural land, puts increased financial pressure on the agriculture sector. In communities that are not competitive locations for new industry investment, policies to help farm households diversify by adding value-added activities might be a viable farm household income stabilization strategy. Smaller firms in competitive markets that have little retail concentration are most likely to introduce new products. Firms that target premium product markets are more likely to be successful.

d. Impact: The more urban growth occurs, the less sustainable the agricultural sector becomes as land prices are bid up. On-farm diversification substitutes for off-farm labor allocation as a farm household income diversification strategy.

d. Source of Federal Funds: Hatch, Smith-Lever

d. Scope of Impact: Indiana

Key Theme: Promoting Business Programs (1)

d. Description: This research studied the interactions among family, family businesses, and community systems in economically vulnerable communities over time. An economically vulnerable community scale has been developed and tested. Research has been completed on the interaction between family and family businesses from the first data collection, and is now shifting to examination of these interactions over time, and whether the interactions between family and family business differ with the economic vulnerability of the community. Findings to date indicate that the economic health of the family is an important factor affecting the success of the family business, but that the economic health of the business does not have a similar impact on the economic health of the family. In addition, household financial resources are used directly or indirectly by about 1/3 of family businesses studied to support the family business, but only 2-3% of family business resources are used to support families (beyond salaries and wages).

d. Impact: Family businesses would benefit from training focused on good business practices, as well as from learning to use family strengths to enhance the business. Some spillover does exist from family to businesses (e.g. role confusion, financial intermingling), and families and their businesses may be at less risk if spillover is contained and boundaries that are satisfactory to the family members are maintained.

d. Source of Federal Funding: Hatch

d. Scope of Impact: Multi-state

5 B. Individual, Family and Community Economic Development

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

b. *Description:* This research explored preschool children's ideas about including or excluding peers with disabilities in play activities. Data were collected from 65 preschool children. Analyses of these data reveal that children's ideas about including a child with a disability in a play activity were related to the demands of the activity and, also, to their own cognitive development. These data provide evidence of the importance of both children's cognitive abilities and situational demands in making decisions about including age-mates with disabilities in play activities.

b. *Impact:* These studies will inform teachers' practices in inclusive programs. Understanding the ways in which social characteristics of groups, and demands of activities, influence children's ideas about including peers with disabilities will help identify effective teaching interventions that support participation of all children.

b. *Source of Federal Funding:* Hatch

b. *Scope of Impact:* National

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

c. *Description:* Research was directed towards enhancing a model of the fiscal impact of development for Indiana counties, municipalities and school corporations. Fiscal impact analysis compares estimates of the added revenues and added costs generated by a new development. Past models have concentrated on accounting for the type of development (residential, commercial, industrial). An enhanced model is being developed to take account of the density of development and the existing capacity of the local governments, in addition to development type. The fiscal impact model will be integrated with GIS models of water quality and wildlife habitat. This would have the advantage of providing a more comprehensive decision-making tool for local officials. In addition, it would improve the user interface by allowing users to draw development types and boundaries on a screen, rather than inputting numbers into cells. Local officials often ask about fiscal impact in a particular way: how valuable must a home be to break even, that is, to generate added revenues equal to added costs. Such calculations will differ for every jurisdiction, and by government type (cities, counties, school districts). It will also depend on the costs imposed on the jurisdiction by the household living in the new home, especially the size of the household and (for school districts) the number of children in the household. Despite these difficulties, a break-even housing value can be calculated for each jurisdiction, and should be an aid to local decision-making.

c. *Impact:* The fiscal impact model will benefit local decision-makers by allowing quicker and easier analysis of the fiscal impacts of development. When combined with the water quality and wildlife habitat modules in a GIS model, local decision-makers will have access to an easy-to-use analytical tool which can produce comprehensive results. This information ought to aid officials in making land-use decisions that are most appropriate for the local community.

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

c. *Scope of Impact:* Indiana

Key Theme: Parenting (1)

- *Description:* Data, including a life history interview protocol, with 40 low-income fathers in a work release correctional facility in Indiana were collected, coded, and analyzed. Four sets of significant findings have emerged from these analyses. First, incarcerated fathers work to maintain complex ties with their children, partners, and extended family members throughout the course of their time in the correctional facility. Second, these fathers in particular rely on the mothers of their children to gatekeep their relationships with their children. Although these mothers both encourage and discourage paternal involvement, site policies tend to exacerbate the isolation of men from their families. Third, many correctional policies regulate spatial movement of men through the community, and men craft strategies to maintain regular contact with their children. Given that family ties have been shown to reduce recidivism, lack of generative policies in the work release facility may actually result in continued expansion of work release offenders. Fourth, using life history data on employment, fathers are actively engaged in jobs that, prior to incarceration, often led to the dissolution of marital or parenting relationships. Men typically work overtime hours and link their substance abuse patterns to stressors associated with work.

- *Impact:* Four primary factors lead to important turning points for low-income, nonresidential men in work-release from a correctional institution in their relationships with their children. Changes in employment can often reverberate in parenting relationships, as well as movement in and out of family households and related shifts in social support from related family members, such as paternal grandmothers. Finally, incarceration, as well as participation in child support and paternity establishment systems, can coincide with transitions in father and child relationships.

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

- Scope of Impact: Multi-state

B. STAKEHOLDER INPUT PROCESS

Engaging stakeholders is a priority for Purdue University. Indeed, the Purdue University Strategic Plan approved by the Board of Trustees in November 2001 makes it very clear that engagement with local, state, national, and world audiences is one of the primary missions of everyone at Purdue University. In the Schools of Agriculture, Consumer and Family Sciences, and Veterinary Medicine, faculty and staff engage stakeholders on a daily basis through activities occurring both within the university setting and across the state and Nation. About one-fourth the faculty in the School of Agriculture have a joint appointment in research and extension. These faculty have extensive interaction with stakeholders through scheduled meetings, on-farm research, problem solving consultations, field days, conferences, etc. Staff participate in a wide variety of state and local events including conferences, commodity marketing associations, and agricultural interest group meetings. Purdue University is reaching new key stakeholders as evidenced by the hundreds of people attending annual horticultural and turf management conferences. In fact, these “green” industry events now attract more participants than the more traditional agronomy or swine field days. Several of Purdue University’s Centers and Institutes that conduct research have external advisory boards which provide input and guidance on the vision for and needs of various sectors of agriculture, including agribusinesses, food processors, state agricultural organizations, and government agencies. Examples include industry advisory boards for the Department of Food Science and the Crop Diagnostic Center. The Center for Food and Agricultural Business trains more than 1,000 agribusiness leaders annually with over 100 days of programmed events. Every session is evaluated by the participants.

Another way our faculty and staff remain engaged with stakeholders is through a highly diverse group of organizations that involve producers and citizens with interests in agriculture and natural resources. Purdue faculty and administrators act as *ex-officio* members or liaisons with 14 of these organizations. These groups are diverse, meet regularly, and are often focused on a particular interest, providing us with an excellent way to interact with a wide cross-section of agriculture interests. The Director and Associate Director of Agricultural Research Programs are both members of the Agricultural Alumni Seed Improvement Association Board of Directors. This facilitates the release of public varieties of wheat and soybeans as well as germplasm. The Associate Director serves as the liaison with the Indiana Soybean Board and coordinates the transfer of soybean checkoff money to faculty under a competitive research grant arrangement. This relationship recently resulted n the funding to support two endowed faculty chairs- one in soybean genetics and one in soybean utilization. The Associate Director is a member of the Purdue University Institutional Review Board for human subjects' research, and he also serves on the human subjects' subcommittee for Extension program evaluation statewide. This not only assures protection of human subjects, but links stakeholders and researchers in program evaluation efforts.

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

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

Purdue Council for Agricultural Research, Extension, and Teaching

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

PCARET holds regional meetings throughout the state in both the spring and fall. At every meeting, representatives from the School of Agriculture attend to update PCARET members on state and national legislative initiatives and programs. An annual meeting for all PCARET members was hosted on the Purdue University campus in November 2003. Indiana has one of the most active and effective CARET organizations in the United States. During the July 2003 Mini-Land Grant meetings hosted by Purdue University, the CARET organization leadership from throughout the North Central Region had an opportunity to learn more about Indiana's PCARET activities and share ideas.

Dean's Advisory Council

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

School of Agriculture Roadmapping

Purdue University has developed, and the Board of Trustees has approved, a Strategic Plan for the entire University. The School of Agriculture completed in 2002 a roadmapping activity to help lay out a plan for reaching "the next level" in learning, discovery, and engagement. Stakeholders from around the state were invited to join administrators and selected faculty at a daylong retreat that kicked off our roadmapping effort. There were subsequent opportunities for feedback from stakeholders as the plan evolved. Stakeholders were asked to respond to three questions: 1) What is the current state of Purdue's agricultural programs?, 2) What should the future look like?, and 3) What steps would be needed to get there? Issues discussed included diversity, research needs, agricultural issues of the future, and economic development. They also helped identify 14 different issue areas to be developed into action plans. The School of Agriculture's Strategic Plan has been approved by the Office of the Provost. Each Department in the School of Agriculture has completed a department-level strategic plan which was submitted to the Dean of Agriculture. Individual departments sought input from their various stakeholder as they developed their strategic plans.

The Purdue University Strategic Plans calls for hiring 300 additional faculty over five years. The Schools of Agriculture, Veterinary Medicine, and Consumer and Family Sciences are all benefiting from these new faculty hires. Priority is being given to three criteria: 1) replacement of Teaching Assistants (TAs) with faculty, 2) cluster hires to focus research and extension expertise on key problem areas where there is a priority need expressed by stakeholders plus funding opportunities, and 3) diversity sensitivity. Last year nearly one-half of the new faculty hires represented women and/or minority hires. This will help Purdue University better reflect the profile of stakeholders that we serve statewide. During 2003, there was substantial progress made in making cluster hires that encourage cross-campus, interdisciplinary research efforts. This is expected to generate additional extramural research funding and help support the Discovery Park research complex currently under construction.

Indiana Crop Improvement Association

Purdue University has a very close working relationship with the Indiana Crop Improvement Association. Faculty are speakers at their annual meeting and share in program planning. There has been a significant collaborative research effort over the past few years that has resulted in the development of CystX™. CystX™ technology can genetically transform soybeans to be resistant to the cyst nematode, a serious soil pest problem in much of Indiana that reduces soybean yields. Some elite soybean varieties are available for planting in 2004, and many more are expected to become available during the next few years. This should help Indiana growers manage the cyst nematode problem and increase soybean yields. Check-off funds through the Indiana Soybean Board have helped finance this effort. This is an excellent example of collaboration among various stakeholders and Purdue University scientists to resolve a major Indiana crop management problem.

Indiana Plant Food and Agricultural Chemical Association

The Indiana Plant Food and Agricultural Chemical Association is composed of individuals from the agricultural service community in Indiana. A typical member sells agricultural chemicals or fertilizers or manages a retail operation. A Purdue University faculty member serves on the board of directors of the Indiana Plant Food and Agricultural Chemical Association in an *ex-offico* status. Meetings of the Indiana Plant Food and Agricultural Chemical Association Board of Directors are held monthly where ideas and issues are discussed. The group also has an active email list and web site where information is exchanged. Individuals from this group also serve on the Advisory Board of the Crop Diagnostic Laboratory which offers educational programs to crop protection professionals.

Office of the Commissioner of Agriculture

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

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

Commodity and Farm Organizations

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

C. PROGRAM REVIEW PROCESS

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

D. EVALUATION OF SUCCESS OF MULTI AND JOINT ACTIVITIES

Faculty associated with the Office of Agricultural Research Programs at Purdue University are involved in over 100 multi-state projects managed through the four Regional Experiment Station Executive Director offices. These projects have a broad disciplinary base. Also all these multi-state research projects are relevant to one or more of the five USDA-CSREES goals. The Office of Agricultural Research Programs reimburses the expenses of those faculty associated with each approved multi-state research meeting. The Associate Director of Agricultural Research Programs is the current chair of the North Central Multi-State Research Committee.

Purdue University is participating in a multi-state project designed to develop information to be used by public sector research administrators and other groups interested in the acquisition of resources for research, in planning and evaluating research, and in managing public research for the maximum benefits to society. This information will assist individual research administrators, regional associations of experiment station directors, legislative aids, OMB, directors of the CGIAR system and administrators of the individual international agricultural research

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

Soybean rust, now widespread in Brazil, has the potential to become a devastating disease in the United States. Purdue University is an active participant in NC-504, a Rapid Response Research Activity committee. This effort is coordinating the assembly of information among USDA-ARS and land-grant scientists through email exchanges, climatological modeling efforts on air mass movements from South to North America that could carry the disease spores, survey design for detection, access to informational websites, research contacts in South America, techniques for potential eradication efforts, and development of educational materials for soybean rust identification and control including approved fungicides, application procedures, and economic thresholds.

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

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

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

Eleven states, including Indiana, are actively involved in a multi-state project addressing adolescent nutrition. Researchers have developed a survey instrument that focuses on key identifiable constructs that may influence the consumption of calcium rich foods among Asian, Hispanic, and White girls and boys ages 11-12 years and 16-17 years. The major themes identified in the instrument are taste preferences, health beliefs (calcium's role in health,

weight concerns, and tolerance), family (family's influence, consumption, and expectations), independence, eating occasions, eating location (school and restaurant), and food availability. Over 1800 children from 10 states (AZ, CA, CO, HI, ID, IN, NV, NM, WA, WY) have completed the initial survey. In Indiana, 446 questionnaires were completed. The results from this project will be used to design effective, tailored nutrition intervention among adolescents with the goal of reducing their risk of osteoporosis later in life.

F. INTEGRATED RESEARCH AND EXTENSION ACTIVITIES

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

Institute Purdue University

State Indiana

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

	Actual Expenditures				
Title of Planned Program/Activity	**FY2000**	**FY2001**	**FY2002**	**FY2003**	**FY2004**
Swine Growth Modeling Extension Project				13,922.84	
Potassium & Phosphorus Nutrition of Alfalfa				30,592.15	
Improving Our Understanding and Interpretation of Soil Potassium Test Results				21,736.94	
Use of Aerator Non-beneficial to Tall Fescue Production				1,854.16	
Strip Tillage: An Increasingly Acceptable Alternative for Corn Producers				11,615.08	
Midwest Fruit Workers				8,437.79	
Soybean Aphid Ecology & Integrated Pest Management (IPM)				28,129.08	
Fungicide Sensitivity Profiles for Indiana Golf Courses				35,460.97	
Food Biotechnology: Dreams from the Fields				6,928.52	
Plants Use Conserved Mechanisms to Regulate the Actin Cytoskeleton and Cell Shape				25,282.69	
Fruit Breeding				51,976.86	
Determining Non-Laying Hens				11,168.40	
Total				247,105.48	

Swine Growth Modeling Extension Project

Pork producers are striving to produce quality lean pork as efficiently as possible with minimal environmental impact. Feed represents approximately 60% of the costs of pork production. Feeding pigs the optimal levels of essential amino acids and phosphorus will reduce feed costs while reducing environmental impact. Recently a feed additive, Paylean™ has been approved to increase the rate and efficiency of lean growth. The use of Paylean™ must take into account the marking system and product system economies.
A stochastic version of the pig compositional model has been developed. The model predicts a compositional growth, live weight growth and feed intake curve for each pig in a 1000 head finisher operation.

Purdue Animal Sciences and Agricultural Economics Departments have developed a stochastic swine growth model that can optimize pork production. This is the first swine compositional growth model that has been developed, parameterized, and tied to a multi-variable decision making program. The program demonstrates that marketing strategies can be improved to increase producer profitability. The feeding of Paylean™ can substantially increase the efficiency of swine growth and profitability. However, the benefits of Paylean™ feeding can only be fully achieved with improved feeding and marketing management. Initial research results indicate that the collection of serial live weight and compositional data as well as development and implementation of the optimal marketing system via animal sorting technology can result in a $7,000 to $10,000 increase in profitability per 1000 head finishing facility.

Potassium and Phosphorus Nutrition of Alfalfa

Farm profitability could be improved by understanding how best to manage P and K for alfalfa production. These two nutrients control alfalfa productivity and persistence, two factors that are important determinants of yield. A long-term experiment is presently examining the impact of P and K on alfalfa yield, yield components, soil test P and K values, plant persistence, root biochemistry, and gene expression.

Purdue University researchers are developing improved phosphorus (P) and potassium (K) fertilizer guidelines for alfalfa in order to maximize long-term alfalfa productivity. Critical tissue and soil test P and K concentrations will be used to determine how much P and K are needed for good agronomic performance of alfalfa. Proper fertilization can double productivity of P- and K-stressed alfalfa. The alfalfa section of the Tri-State Fertilizer Extension Bulletin will be revised as a result of this research. This Bulletin is widely used by farmers and crop consultants.

Improving Our Understanding and Interpretation of Soil K Test Results

Without moldboard plowing, K becomes stratified in the root zone. Concentrations are greatest in the surface soil (top 2 to 4 inches), but this K may be relatively less plant-available, especially during dry periods, than it would be if it were deeper in the soil profile. To date, studies have not addressed whether this stratification requires a change in K management recommendations. Furthermore, current laboratory analyses index exchangeable K only and do not address fundamental differences in soil physiochemical properties are not well correlated among all major agronomic soils. A NaBPh4 extraction has shown promise in greenhouse research for indexing K availability among soils but field correlation/calibration work has not been done. This project is using soil and crop data and archived samples (currently being analyzed) from a 6 year, 5-location K-rate experiment established in 1997 at five regional Purdue Agriculture Centers. Field sites were established in 1997 at locations representative of different major agronomic soils of the humid region of the Eastern Corn belt. Treatments included crop species, rotational corn and soybean (both crops present each year), and K fertility level (rate and timing of application). Data from intensive soil and plant sampling regimes are being used to construct a K balance for six crop cycles (3 full rotations). Soil nutrient absorptive strength, soil buffering power, and soil quantity/intensity relationships are being evaluated with depth in the soil profile for their effect on plant-

availability of K. Data are being analyzed for soil test critical levels needed in surface soils to attain optimal yields and grain quality.

Potassium fertilizer is a multi-billion dollar investment for U.S. farmers and, in Indiana over 70% of agricultural soils are inherently K deficient. Soil testing remains the cornerstone of K fertility recommendations for production agriculture, but current laboratory analyses are not well correlated on all agronomic soils in Indiana. Furthermore, large within-field variability in soil K supply typically exists, and soil sampling strategies that accurately characterize this spatial variability can be a major investment. Accurate soil K test information and efficient collection strategies are essential to optimizing returns on fertilizer investment. This research is creating the database needed to improve K management recommendations for corn soybean rotations in the eastern Corn Belt and to optimize farmer investments in precision technologies, soil testing and K fertilizer. This research will permit the complete revision of the university K recommendations to include soil- and crop-specific interpretation of soil test results and guidance on how to mange K fertility to maximize yields in both low and high yielding environments. Project results will also provide a foundation for future research on fertilizer placement and genetic differences in plant K uptake and use. Completion of this effort will have major agronomic and economic implications for Indiana farmers and the fertilizer industry.

Use of Aerator Non-beneficial to Tall Fescue Production

The cool-season grass tall fescue occupies over 30 million acres in the United States. Most of the acreage is in the transitional zone between cool, temperate climates and subtropical climates. Southern Indiana is the north central region of the zone that is commonly referred to as the Tall Fescue Belt. Much of the forage acreage in this region is acidic and/or deficient in nutrients for satisfactory establishment and production of many forages. With perennial forage crops it is difficult to incorporate needed nutrients into the soil profile as fertilizers are typically surface-broadcast applied. Aerators, implements that were developed to improve soil physical properties, have not been evaluated in regards to incorporating surface-applied fertilizer deeper into the soil profile.

Field research was conducted on tall fescue hay and pasture sites at the Southern Indiana Purdue Agricultural Center in 2001 and 2002. The objectives of the research were to determine if the Aerway aerator 1) incorporated broadcast-applied phosphorus (P) and potassium (K) fertilizers, 2) improved forage yield and/or 3) improved forage quality.

Investment in the Aerway aerator for the purpose of incorporating P and K fertilizers, and improvement in tall fescue forage yield and quality is not justified. Aeration did not improve soil nutrient distribution at deeper depths in the soil profile. Greater than 50 percent total soil P and total soil K remained in the upper 2 inches and 4 inches, respectively, in the 8-inch sampling zone. Aeration had no consistent positive effect on dry matter yield or forage quality. In most cases, aeration reduced yield.

Strip Tillage: An Increasingly Acceptable Alternative for Corn Producers

Adoption of the no-till system for corn reached a peak of about 25% of the acreage in 1995, and has plateaued at about 20% in the period since. Corn farmer concerns for possible delayed planting and poor plant establishment due to the cooler and moister soils associated with no-till, relative to conventional tillage systems has been the main impediment to further adoption of no-till for corn. Even though farmers have widely accepted no-till for soybeans (at about 60% of the acreage each year), the same conservation practice has not occurred for corn production. This has resulted in continued high costs and increased erosion potential. Research and extension team efforts have widely promoted fall strip tillage as an acceptable compromise alternative between no-till and full-width conventional tillage systems.

These research and extension efforts on strip tillage are another essential part of the growing confidence in strip tillage as a new conservation planting system for corn in Indiana and surrounding states in the Corn Belt.

Furthermore, research efforts on multiple strip-till equipment depths and fertility placement are providing much needed support information on how to achieve best possible results with this relatively new system. Fall strip tillage is now the fastest growing tillage system (in terms of estimated percentage increase) in the last 3-5 years. It has been adopted by farmers on both ends of the tillage spectrum; no-till farmers have converted to it in place of continuous no-till, and conventional-till farmers have converted to it to save input costs and reduce soil erosion. Because the only tillage with strip tillage is in the intended row areas for corn (usually planted on 30" centers), strip tillage has combined the best of both tillage alternatives. It preserves from two-thirds to three-quarters of the surface residue cover of no-till, and it permits soil drying and warming in spring to be as fast as it is after fall conventional tillage operations. Thus, more corn farmers are being reassured that planting dates need not be delayed (as it might be for no-till on poorly drained soils in some springs), and that early corn growth rates and final yields are comparable to those with conventional tillage. Furthermore, the soil savings with strip tillage preserves long-term productivity.

Title Midwest Fruit Workers

The Midwest Fruit Workers consists of Extension personnel with responsibility for fruit from 11 Midwestern states; Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Missouri, Nebraska, Ohio, West Virginia and Wisconsin. This group meets annually at the Midwest Fruit Workers Conference in Indianapolis to work on cooperative publications. Each year, the Commercial Tree Fruit Spray Guide and Midwest Small Fruit and Grape Spray Guide are revised and updated to provide growers with the latest information regarding pest management alternatives. Other publications produced by this group include Midwest Tree Fruit Pest Management Handbook and Midwest Small Fruit Pest Management Handbook. Publications targeted at home fruit growers include Tree Fruits: Insect and Disease Management for Backyard Fruit Growers in the Midwest and Small Fruits: Insect and Disease Management for Backyard Fruit Growers in the Midwest. For each of these publications, the pooled knowledge of Extension specialists from all the cooperating states is merged to produce a single set of recommendations that are used throughout the region. In addition, 5 entomologists from Illinois, Indiana, Kentucky, Missouri, and Ohio are working cooperatively to evaluate new, safer pesticides for control of codling moth, the primary insect pest of apples. They are also testing non-chemical control of codling moth with innovative methods of mating disruption using pheromones.

By combining the expertise of Extension specialists from a number of states, the publications produced are more comprehensive than those that could be produced by individual states. A single, consistent set of recommendations is used throughout the Midwest. These publications are the primary source of pest management information for commercial fruit growers in the cooperating states. For states that are unable to devote much Extension involvement in fruit production, such as Kansas, the Midwest Fruit Workers provide materials that can be used to meet the needs of their clientele. The result is that commercial and backyard fruit growers throughout the Midwest having the latest information regarding fruit production and pest management. In the area of pest management, the result is that fruit growers will use the correct pesticides for particular pests at the proper time, resulting in improved control, less overall pesticide use, and reduced pesticide residues on fruit crops.

Soybean Aphid Ecology & Integrated Pest Management (IPM)

Prior to the invasion of the soybean aphid, soybeans in the U.S. North Central Region typically did not suffer intense pressure from insect pests. The infestation of the aphid now extends over a 20 state area challenging pest managers to develop new approaches to managing this serious pest of soybean production. Purdue Extension, several Purdue departments and multi-state collaborators are helping define sampling protocols, management thresholds, aphid-natural enemy ecology relationships, and primary-secondary hosts associations. The range of reported yield losses in Indiana and other mid-western states amounts to tens of millions of dollars, annually. Purdue research is providing pest managers key information on aphid-host relationships, the effects of soybean production practices on aphid densities and damage, and the importance of natural enemies on aphid dynamics and control. This research is providing soybean producers effective and environmentally-sound methods of

managing this devastating invasive pest by: 1. Aphid-host relations: Understanding which species can serve as hosts, and their relative distribution and abundance, allows pest mangers to map out areas at higher risk, and mobilize scare resources to manage the insect before it reaches pestifierous levels. 2. Soybean production practices: Determined that aphid population densities and growth rates were not affected by plant age (planting date). A statewide survey of aphid densities showed that the northern one-half of the state was heavily infested, and insecticides were commonly applied there. These findings will impact management decisions and identify areas of risk where management efforts can be focused. 3. Endemic natural enemies: The impact and ecology of endemic natural enemies has shown that predators present in the field before aphids arrive can have a significant effect on subsequent aphid densities, however, this impact is influenced by the presence of alternative prey. These findings will impact early-season pesticide application decisions as well as form the basis for preventative pest management practice for soybean aphid IPM.

Fungicide Sensitivity Profiles for Indiana Golf Courses

Dollar spot is a problem on every golf course in the state. Although the disease does not kill the grass, it results in a poor appearance, reduces playability and predisposes turf to contamination by weeds. The disease is active from May through October, and is aggravated by more intensive turf management practices. Because nearly half of the pesticide budget is used for dollar spot control, superintendents are interested in the sensitivity of dollar spot strains on their golf courses to common fungicides for disease control. Purdue's turf pathology group in the department of Botany and Plant Pathology conducted assays to determine the fungicide sensitivity of the dollar spot pathogen population on Indiana golf courses. The initial survey included isolates of the dollar spot fungus from seventeen courses. To date, more than 300 isolates have been collected representing 40 - 50 courses. Each participating golf course was provided a fungicide sensitivity profile which described expected disease control efficacies for three common fungicides.

With these fungicide sensitivity profiles, superintendents gain awareness of the dollar spot threat on their own golf courses and often change their management practices accordingly. As a result, they are likely to apply less fungicide while maintaining an attractive high quality playing surface. Benefits include reduced fungicide expenditures, less pesticide added to the environment, and a greater likelihood of applying the most appropriate fungicide to control disease. More than 75% of the respondents to a follow up survey indicated that the results of our work increased their awareness of fungicide resistance issues. More than half of the respondents indicated that they will change their management practices based on this new information. More than 80% indicated that the information will help them develop improved long term strategies for resistance management. Comments added to the survey included the following: "This is one of the most helpful pieces of information I have ever received." "Good program to continue. We are thankful for your work and hope it continues..." "This will be a very valuable practice tool for use by the golf course supt. I believe the research will help better organize chemical programs, save money and eliminate certain unneeded chemical applications." "As an environmentally conscious Superintendent managing a Certified Audubon Cooperative Sanctuary, I also appreciate this research because of the beneficial impact it will have on the environment. Without this data, it's very possible that less effective fungicides would unnecessarily be applied more frequently and at higher rates."

Food Biotechnology: Dreams from the fields

An August 2002 survey by the International Food Information Council (IFIC) found that only 35% of American consumers were aware that foods from biotech crops were sold in supermarkets. Current estimates are that 80% of all processed foods contain ingredients from genetically-modified plants. The lack of understanding by American consumers about this new technology may lead to the same lack of confidence in food systems that have been expressed by European consumers and grocers. Providing American consumers with science-based information will allow them to make informed decisions regarding the acceptability of these products. Department of Foods and Nutrition cooperative extension efforts have developed and delivered a training program to provide science-based information to physicians (3,800), registered dietitians and nutritionists (105), food technologists (323), k-

12 science teachers (114), cooperative extension educators and specialists (184), producers and producer groups (597), college students (2,493), toxicologists (100), biotech industry personnel (29), miscellaneous professionals (40), food service workers (100) and consumers (1,103). Through a program entitled 'Food Biotechnology: Dreams from the fields', Purdue faculty have provided training to 8,988 people in three countries (USA, Philippines, Mexico) with 1,353 participants completing an assessment survey including over 826 that completed pre- and post-training surveys to determine the outcome of training on participants knowledge and attitudes.

Following training, 98-99% correctly indicated that fruits and vegetables contain chromosomes and foods from biotech crops are currently sold in grocery stores. Prior to training, only 31% felt that these crops were properly regulated by federal agencies and only 25% were confident that bioengineering was unlikely to make an existing food allergenic. Following training, 83% felt that these crops were properly regulated and 63% believed that biotechnology was unlikely to add new allergens to our food supply. In addition, 90% of those trained would eat or serve genetically-modified foods to their family and 90% believed that they or their family would benefit from genetically-modified foods within the next 5-years. It is apparent from these results that when provided sound, science-based information, participants are more accepting of this technology and the regulatory process.

Plants Use Conserved Mechanisms to Regulate the Actin Cytoskeleton and Cell Shape

A better understanding of plant cell growth mechanisms is needed if future efforts to alter the physical and chemical properties of plant cells are to be widely successful. Data demonstrate the importance of the ARP2/3 complex in the generation of a normal actin cytoskelton during cell growth. Molecular genetic and cell biological experiments using Arabidopsis will help to understand how signalling processes affect the actin cytoskeleton during growth and development. Recent gene cloning experiments have shown that an evolutionarily conserved ARP2/3 complex is required for normal cell growth and development.

The actin cytoskeleton plays a central role in plant growth by providing both tracks for transport of new wall materials for growth, and perhaps a driving force for organelle transport. Understanding the mechanisms by which the actin cytoskeleton is reorganized will permit more rational engineering of plant cell and organ architecture.

Fruit Breeding

Indiana horticulture requires new high quality, disease resistant cultivars of apples and pears. The apple breeding program is a cooperative effort with Purdue University, the University of Illinois and Rutgers, The State University of New Jersey.

Two high quality, disease-resistant apples have been released: Pixie Crunch, a red very crisp apple that should appeal to children, and Sundance, a yellow apple with resistance to many diseases including apple scab. A new pear with tolerance to the disease fireblight has also been released: Green Jade. These new cultivars of apple and pear should provide new options for Indiana fruit growers and Indiana home owners who grow fruit in their yards.

Determining Non-Laying Hens

On average, nearly 28% of all layer hens fail to lay. This additional housing and feed cost poultry producers millions of dollars annually. A method has been established to selected identify non-laying or low producing hens. Through this selection procedure, Purdue can assist poultry producers in the selection of non-laying or low producing hens. This method of selection can effectively reduce 1 to5% of the non-layers in a flock, which in turn increases the overall profitability of a layer operation.