North Carolina Agricultural Research Service

Annual Report of Accomplishments and Results

2003

AREERA REPORT

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North Carolina Agricultural Research Service
College of Agricultural and Life Sciences
North Carolina State University
Campus Box 7643
Raleigh, North Carolina 27695
http://www.cals.ncsu.edu/research

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Introduction and Certification

North Carolina State University is North Carolina's 1862 land-grant university and the only Research I land-grant institution in the state. The North Carolina Agricultural Research Service (NCARS) within the College of Agriculture and Life Sciences serves not only as the college's agricultural, environmental and biological sciences research arm but also provides the research foundation in these areas for educational activities within academics and extension. NCARS is the principal state agency for research in agriculture, life sciences and forestry. Its research projects involve North Carolina State University's colleges of Agriculture and Life Sciences, Forest Resources, Physical and Mathematical Sciences, Engineering, and Veterinary Medicine and the School of Human Environmental Sciences at the University of North Carolina-Greensboro. Within the college, NCARS coordinates research in 18 departments and works in partnership with the North Carolina Cooperative Extension Service and Academic Programs.

The mission of NCARS is to develop the knowledge and technology needed to:

- improve the productivity, profitability and sustainability of industries in agriculture, forestry, and life sciences;
- conserve and improve the state's natural resources and environment; and
- improve the health, well-being and quality of life of all citizens of North Carolina.

In FY 2003 NCARS personnel include 297 tenured and tenure-track research faculty accounting for approximately 197 full-time scientist equivalents, most on shared appointments with academics or extension. Working with these faculty members are over 393 research professors, researchers, research assistants and graduate students; 445 laboratory and field technicians and 168 clerical staff. These faculty members and support personnel conduct basic and applied research in 616 projects to support more than 70 commodities as well as many related agribusinesses and life science industries.

The following Plan of Work Annual Report highlights accomplishments and impacts of research conducted through the North Carolina Agricultural Research Service and emphasizes the high priority areas in agriculture and life sciences for North Carolina now and in the near future.

Steven Leath, Interim Director and Associate Dean
North Carolina Agricultural Research Service
Campus Box 7643
North Carolina State University
Raleigh, NC 27695

A. Planned Programs

National Goal 1: An Agricultural System that is Highly Competitive in the Global Economy

Overview: Animal and Plant Production Systems

Plant Systems

North Carolina has always had a strong agricultural economy, however it has become more diverse to meet the demands of a changing population and market opportunities. Growers have diversified into many specialty crops including medicinal herbs, specialty melons, heirloom fruits and vegetables, various crops for the state's growing Hispanic and Oriental populations, kenaf, sea oats and winegrapes. Additionally consumer concern over food quality and nutrition has fostered an increasing demand for organically produced fruits and vegetables. While this diversification has been good for North Carolina growers, it has placed demands on the NCARS to develop sustainable programs for producing, managing pests and pathogens, harvesting and storing these commodities.

The performance goals under Goal 1a address needs of North Carolina growers which will allow them to remain competitive in a national and global agricultural economy and take advantage of local marketing opportunities through more efficient production practices and diversification to alternative and specialty crops. The target audience for this research is the producers of field and horticultural crops in North Carolina, however much of the research will have regional, national and international impact. Additionally, North Carolina consumers will benefit through increased diversity of fresh, locally grown produce in the marketplace.

Performance goal 1 focuses on the development of improved pre- and postharvest handling techniques for field, fruit and vegetable crops.

- A sweetpotato harvesting aid (vine puller), designed to reduce injury to sweet potatoes during harvest and postharvest handling, was designed and tested.
- A technique for use of the postharvest product SmartFresh was developed for apple growers with limited acreage and resources. SmartFresh improves the quality of stored apples and has the potential to open new markets for high quality apples produced in North Carolina.

Performance goal 2 addresses improved production management systems for field, fruit, and vegetable crops and includes a wide range of projects that focus on various management practices.

- Studies conducted at the Center for Environmental Farming Systems focused on projects related to the biological basis, agronomic value, and economics of various production systems including conventional growing systems using best management practices, integrated crop and animal systems and all organic systems.
- Another found that yields could be increased by over 50 bu/ acre if the seeding rate of corn was increased and plants uniformly spaced.

- A related project found that corn yield could be increased by 40 bushels/acre if the crop was planted at the optimum date. Studies on various new herbicides found that improved weed control could be achieved, often with significant savings.
- Equipment, software and field procedures were developed to enable comparisons of nitrogen application and preplant tillage treatments in conventional and precision agriculture crop production systems.
- Studies showed that nitrogen use in corn and wheat fields can be optimized by using aerial color infrared photography to determine where and how much nitrogen fertilizer is needed. A nitrogen recommendation model for corn, based on in-season color-infrared photographs, was validated and could save growers 25 to 50 pounds of nitrogen per acre with no loss in grain yield. These studies produced direct savings for growers and optimized fertilizer-use, minimizing the amount of excess nitrogen that can pollute ground and surface waters.
- A multistate project on integrated weed management resulted in the creation of versions of the family of decision aids, HADSS (Herbicide Application Decision Support System), WebHADSS, and Pocket HERB, customized for each of 10 states. Databases for seven states have been made available to users. HADSS 2003 and Pocket HERB 2003 were released for commercial distribution through AgRenaissance Software LLC in late summer 2003. WebHADSS 2003, a web-based version of HADSS for use by extension personnel, consultants and growers, was released in spring 2003.

Performance goal 3 focuses on improving the acceptability and quality of field, fruit and vegetable crops. Since quality and yield parameters are usually considered along with those for pest resistance, results of many of the breeding projects are reported under Goal 1, Program Area 2.

- One study found that pollinizing systems for watermelons that use new pollinizers that take up less space, increased the yield of seedless watermelon by 10-25%.
- A procedure was developed for identifying transgenic plants that do not require activity of a marker such as those conferring antibiotic resistance. Use of this procedure could help remove one of the barriers to public acceptance of transgenic plants and plant parts.

Performance goal 4 includes research projects that are related to the development of improved production management systems for ornamental and floricultural crops and turfgrass.

- A broad range of projects addressed problems related to the production, culture, breeding, pest management, culture, taxonomy, and other areas of plant production.
- Through the selection and development of pest resistant ornamental plants, the need for pesticides for such diseases as apple scab, dogwood anthracnose, fire blight of apple, and powdery mildew on a number of plant species has virtually been eliminated.
- A turfgrass project identified cultivars of bermudagrass that have superior establishment rates, recovery from traffic, pest tolerance and cold weather.

Performance goal 5 focuses on the development and introduction of superior landscape plants to enhance rural and urban environments. The two projects under this goal focused on the evaluation of plants for the landscape in the Southeastern United States, which is one of the missions of the J.C. Ralston Arboretum at North Carolina State University, and evaluation of trees species for planting in the various regions of North Carolina.

- Over 500 species and cultivars of bedding plants were rated under sun and shade conditions, including many unnamed experimental hybrids being evaluated for environmental tolerance for the first time.
- The propagation protocol was examined for species within the genera *Ternstroemia*, *Lindera*, and *Quercus* with propagation stock from specimens within the Arboretum's collections.
- NCARS projects developed new cultivars of the butterfly bush, sweetshrub, and ornamental sweetpotatoes. Each of these has worldwide market potential.

Animal Systems

Faculty and staff at North Carolina State University have been engaged in a wide array of research and related projects to increase the competitiveness of North Carolina animal agriculture and improve its global economic position. These efforts are very broad in scope, impact, and clientele served. Major concerns include improving animal health, production efficiency, and profitability while at the same time improving overall environmental conditions and ensuring the sustainability of our rural communities. These concerns receive intense effort for integrated animal agriculture as well as for diversified, alternative, and small independent producers. Projects are conducted within university campus resources and across the state working cooperatively with North Carolina producers, citizens, and other stakeholders.

The North Carolina State University Animal and Poultry Waste Management Center was established to address waste management issues, to find ways to ensure the vitality of the state's important animal and poultry production industries, to seek opportunities for adding value from waste byproducts, while also protecting the environment. Waste management technology development and performance evaluations, including economic feasibility determinations, will provide the industry and North Carolina policy makers and others with scientifically based information. This information will allow policy makers to make informed decisions that will affect the environment and an important segment of the state's economy. Other environmental work includes:

- The study of alternate hog waste treatment technologies, including statistical models to compare potentially superior systems to each other and to currently popular systems;
- Planning for a closed system of integrated technologies to reduce the environmental impact of swine production;
- Evaluation of a farrow-to-weaning swine farm with a covered anaerobic digester for primary waste treatment, a conventional lagoon for temporary storage, a generator for production of electricity from biogas produced, and a greenhouse for utilization of nutrients from the effluent;
- A study that found that feeding degermed-dehulled corn reduced swine waste production approximately 40% while possibly reducing odor emission without negative effects on animal performance.

Improving animal health and production efficiency were addressed.

- One project resulted in findings regarding treatment of redmouth in trout whereby over 60% of trout produced on farms in 2003 were protected by injection vaccination.

- Investigation of direct-fed microbials (DFMs) to reduce gamebird mortality resulted in significant reductions in deaths of these birds, resulting in over 75% of gamebird producers nationwide adopting the use of DFM in their feeds.

A number of projects involved improving animal production efficiency or profitability. With over 60% of farm gate receipts coming from animal production, this work is very important to the farm economy of North Carolina.

- New feeding regimes developed at NC State University have resulted in a 27% improvement in feed conversion efficiency in hybrid striped bass translating into a potential savings of nearly $1.25 million for North Carolina hybrid striped bass producers.
- Water supplementation of Mg on swine farms appears to be effective in improving pork quality after a very short supplementation period.
- Heat-stressed dairy cows treated with intra-vaginal progesterone releasing devices increased pregnancy rates from 20% in control cows to 35% in the CIDR group.
- Over 5,000 tons of recycled poultry litter, 7,000 tons of soybean hulls, 4,500 tons of dry corn gluten feed and 6,000 tons of wet corn gluten feed, and 5,000 tons of other miscellaneous byproducts were utilized by beef cattle producers for a realized savings of over $1 million.

Biosecurity of animal production farms is extremely important for animal health as well as food safety. Efforts to improve biosecurity can be in the form of improved understanding and management of micro-flora or through public education programs.

- *Staphylococci* are one of the most prevalent bacteria causing infections in humans and animals resulting in morbidity and mortality. The major *Staphylococcus aureus* strains associated with mastitis in dairy cattle were shown to be capable of persisting for 10 years or longer on their hosts, and a significant portion of their population can survive antibiotic therapy even though they are susceptible as shown by *in vitro* testing.
- Other studies are underway involving NC State and Ohio State University researchers to identify and test a number of potential alternative animal waste management and treatment technologies as to their ability to reduce the human disease risk associated with modern animal agriculture.

FTEs & Program Cost for Goal 1
Program cost is inclusive of federal Hatch funds appropriations, other federal contracts and grants, state appropriations, and other contracts and grant funds.

Federal App.	State App.	Fed G & C	Non Fed Grants	SY	PY	TY	CY
$3,787,255.09	$31,206,393.28	$17,228,909.09	$5,874,585.45	99.6	199.9	227.4	39.72

Key Themes: Plant Systems

Key Theme: Agricultural Competitiveness

a. Issue: To remain competitive in a national and global agricultural economy, it is necessary for producers to become more efficient in the production of traditional crops. A number of NCARS projects are underway that involve studies on ways to more efficiently use fertilizers and herbicides.

b. Impact: Research showed that both variable rate nitrogen and the current "whole-field" nitrogen optimization systems for small grains resulted in significantly higher yields, higher net profits and higher nitrogen use efficiency compared to typical North Carolina growers' practices.

c. Scope of Impact - State specific but will have regional impact.

Key Theme: Agricultural Profitability

a. Issue: In recent years low grain and cotton prices and pressures exerted on tobacco production have resulted in reduced farm profit and the redirection of programs within NCARS to examine ways to diversify of crop production in North Carolina. These studies have led to the planting of specialty crops such as medicinal herbs, specialty melons, heirloom fruits and vegetables, editable soybeans, and winegrapes.

b. Impact: Trials conducted in a tobacco transplant greenhouse showed that native plants for use in streambed and wetland restoration programs and for storm water control could be successfully produced off-season in these facilities. Several growers have already adopted the native plant production and marketing recommendations.

c. Scope of Impact – State Specific but may have regional use

Key Theme: Plant Production Efficiency

a. Issue: Efficient production practices are an essential component of competitive and profitable production systems. NCARS research projects address this need through studies on optimum row configurations, planting date, polymer seed coatings and planting density for corn, and different irrigation systems as they affect peanut yield and disease incidence and severity. Other studies have focused on optimizing the use of fertilizers and herbicides in various cropping systems including cotton, soybean, corn and peanut.

b. Impact: Rates of the herbicide Strongarm can be reduced 84% and still control common ragweed, the most troublesome and competitive broadleaf weed in North Carolina peanuts. This treatment results in producers saving at least $18 per acre, and compared to the current commercial standard, also results in a 99.5% reduction in herbicide active ingredient.

c. Scope of Impact – State specific

Key Theme: Precision Agriculture

a. Issue: Precision agricultural techniques are important components of efficient crop management programs. Several NCARS projects have focused on using color infrared photography to aid in the application of fertilizers and various crop production chemicals.

b. Impact: Infrared photography in corn and wheat fields was shown to aid in determining where nitrogen fertilizer is needed and in what quantity. These projects have the potential to optimize nitrogen-use efficiency, by tailoring site-specific fertilization and liming of row crops to spatially variable soil properties that affect crop yield. Additionally optimizing fertilizer-use efficiency will minimize the amount of excess nitrogen that can pollute ground and surface waters. Field studies found that color infrared photographs used in conjunction with field scouting could accurately determine the rates of the growth regulator mepiquat chloride needed for controlling cotton growth, resulting in a reduction in scouting and chemical costs of $27/acre with an increase in harvestable yield.

c. Scope of Impact – Southeast region and possibly other cotton growing regions

Key Theme: Ornamental/Green Agriculture

a. Issue: The $1 billion dollar "green" nursery industry in North Carolina is the number one crop commodity in the state in revenue. New cultivar development is an important component in maintaining a dynamic and forward-looking industry.

b. Impact: *Buddleia* (butterfly bush) is a popular ornamental nursery plant with invasive pest-plant tendencies. At NC State University, controlled hybridizations between *Buddleia* parents with differing chromosome number resulted in the development of offspring with excellent ornamental attributes and sexual sterility. Development of sterile ornamental forms of *Buddleia* will allow continued deployment of this widely used ornamental shrub in the landscape without the risk of fertile seed being spread into natural ecosystems and native plant communities. Furthermore, availability of sterile *Buddleia* will allow the nursery industry to develop new promotion and marketing strategies for the new cultivars, and increase the acceptance and use of this plant in the home landscape

c. Scope of Impact – State and National

Key Theme: Plant Germplasm

a. Issue: A study of the evolution of different genes in *Arabidopsis thaliana* was completed, providing information on how development evolves. QTL mapping technologies were used to look for genes that control important life history traits, particularly in field ecology settings. This research provides significant information on how genetic variation may be distributed in plant species.

b. Impact: This information is vital to attempting to understand how to strategically sample crop germplasms for future use in breeding experiments. Understanding the genetic basis of flowering and flowering time may also provide new avenues to manipulate these traits in crop plants.

c. Scope of Impact - National

Key Theme: Agricultural Financial Management

a. Issue: Data from an extensive farm-level survey of U.S. agriculture have been used to model the extent to which the decoupled farm program payments (often called AMTA payments) that were

provided to U.S. farmers may actually have had production effects. Economic theory predicts no effect, though to the extent that farmers are capital-constrained or have risk preferences that are influenced by such payments, effects may occur. We have provided econometric evidence that suggests that these effects, though statistically significant, are relatively minor.

b. Impact: The production-neutral nature of U.S. farm programs is pivotal in the current WTO negotiations on agriculture. The EU has argued that such payments, which are an important cornerstone of the 2002 Farm Bill, should be regulated by the WTO because of their substantial distorting effects. Our research calls such a view into question. About $36 billion was transferred to U.S. farmers during the last Farm Bill using such decoupled programs. Our research has been used in policy discussions by the USDA and the OECD.

c. Scope of Impact - National

Key Themes: Livestock Systems

Key Theme: Adding Value to New and Old Agricultural Products

a. Issue: The poultry industry continues to seek new and alternative litter materials for rearing poultry. While many materials have been identified and tested, very few have replaced pine shavings, which has served as the standard and most used bedding material. However, shortages of pine shavings will become more prevalent as new and more valuable uses for pine shavings are developed. However, many industry personnel believe that the quality of pine shavings used as poultry liter has declined in recent years. This may be due, in part, to differences in saw design used for milling lumber resulting in a smaller wood particle size. A novel litter material (agro-chips) has been made from old newsprint, cotton waste, and gypsum. This material has is very absorbent but also has a high drying rate. It can be processed into a material that might be suitable for poultry bedding. The objective of this study was to determine if agro-chips can serve as an alternative litter material equal to that of pine shavings.

b. Impact: Birds reared on pine shavings (PS) were compared to birds reared on agro-chips. The use of agro-chips litter resulted in heavier toms and hens at 20 wk There were no differences in feed conversion or carcass yield due to litter type. All the pens in this study had considerable caked litter by the end of the rearing period. Further testing under field conditions is desirable to compare agro-chips litter to pine shavings under commercial conditions. In conclusion, agro-chips litter is a potential alternative litter material to pine shavings.

c. Scope of Impact - State specific

Key Theme: Agricultural Profitability

a. Issue: Misdiagnosis of estrus is the most common human error made on sow breeding farms. It is costly, time consuming and significantly compromises animal welfare and profitability. Sows that are bred at the incorrect time during estrus have poor reproductive performance and are at an increased risk of developing reproductive tract infections, which can permanently affect their fertility.

b. Impact: Researchers in the Department of Animal Science have worked with InterVet, Inc., the North Carolina Pork Council, and the National Pork Board to develop management strategies for synchronization of estrus in swine. This research collaboration has resulted in the first F.D.A. approved product for estrus synchronization in mature swine. Economically, it has been estimated that this costs the U.S. swine industry between $30 to $90 million annually. Implementation of estrus synchronization programs on farms significantly reduced mistakes in detection of estrus. When this occurred, reproductive performance, sow longevity, and profitability all increased.

c. Scope of Impact - State Specific

Key Theme: Animal Health

a. Issue: The upland wild gamebird industry has nearly doubled in the past 30 years. Approximately 4,000,000 Bobwhite quail, Ring necked pheasants, Chukar and Hungarian partridges, and Mallard ducks are produced in NC each year. There are approximately 40,000,000 of these birds produced nationwide each year. Most of these birds are sold to hunting preserves rather than for meat production. The game bird production and hunting preserve industries represent an approximate $1 billion contribution each year to the US economy. In production of these birds, it is common for producers to experience mortality rates as high as 30%. In the past, there has been very little expertise and educational information available to help breeders and producers of these birds.

b. Impact: In many field and research trials, it was found that DFM's have a profound effect on reducing mortality, increasing body weight growth, reducing feed efficiency, increasing feather quality, and increasing flight ability. Due to the success of the field and research trials, over 75% of game bird producers nationwide now use a DFM in their feeds. Producers proclaim a significant reduction in mortality and a significant increase in feather quality and flight ability in their birds.

c. Scope of Impact - State Specific and National

Key Theme: Animal Production Efficiency

a. Issue: Broiler breeders have historically been grown to achieve empirically-derived body weight standards suggested by the private poultry breeding companies that supply the breeding stock to the domestic and international broiler industry. Recent work at NC State has shown that it is better to feed the breeding stock to reach certain cumulative nutrient intake goals for crude protein and metabolizable energy during rearing, irrespective of body weight, in order to obtain optimum fertility and egg production. The next question was whether modifying the cumulative nutrient intake during rearing would also affect broiler progeny performance, especially from very young broiler breeders that have historically produced chicks that grow slower than average. It was hypothesized that a higher plane of rearing nutrition may allow early lay broiler breeders to produce better performing broilers.

b. Impact: Broiler trials were conducted using chicks hatched from broiler breeder females reared on a range of cumulative nutrition in three consecutive broiler breeder trials. The broiler breeder pullets were fed three graded levels of cumulative crude protein (CP) and metabolizable energy (ME) intakes (High (27,788 kcal ME and 1485 g CP), Medium (26,020 kcal ME and 1391 g CP), and Low (24,242 kcal ME and 1296 g CP)) to 21 weeks of age when photostimulation was used to initiate the final stages of sexual maturation. As a point of reference, the Low plane would be typically used

commercially. A single breeder laying diet and identical management practices were applied to broiler breeder females in all three trials. Chicks were hatched from eggs laid by the broiler breeder females and then were fed the same broiler starter diet in crumble form to 21 days of age to evaluate the vertical effects of broiler breeder female rearing nutrition in a standard manner. The high plane of cumulative broiler breeder female rearing nutrition significantly increased 21-day broiler male body weight of chicks hatched from eggs produced by broiler breeders at 27 weeks, 28 weeks, and 33 weeks of age. The fact that only male progeny were consistently affected suggests a sex-linked effect that must derive from fundamental differences in genetic expression at the molecular level. A major component of the North Carolina poultry industry and economy are the over 9 million broiler breeders that produce fertile hatching eggs from which broiler chicks hatch. These fertile hatching eggs supply over 20% of all the broilers (almost 2 billion) grown in the USA annually. An increase in male broiler body weight of 0.05 pounds produced by feeding broiler breeders more feed during rearing will have a value of $ 3 million annually in the USA.

c. Scope of Impact - State and national

Key Theme: Biofuels

a. Issue: Due to the mixing of urine, feces, and water, ammonia and odor emissions are common from swine houses, and the resulting waste is difficult to further process into value-added products. In addition, swine excreta harvested dry contain large amounts of energy that in the current lagoon systems go unutilized.

b. Impact: A belt system was evaluated for harvesting swine excreta. This system was designed such that urine and feces are passively separated, resulting in a dry fecal stream. Dry harvested swine waste was evaluated as a feedstock for the production of energy sources such as electricity and ethanol. Remnants of this process are ashes that can serve as a feed ingredient for livestock, thus recovering minerals such as phosphorus. Swine housing equipped with belts resulted in 75% less ammonia emission, substantially lower odor emission, and waste streams that are more flexible in their use. The combination of the belt system for harvesting swine manure and conversion of the excreta to an energy source may be used to build a ‘waste-free’ swine production system. Excreta are converted to valuable fuel, and ash is recycled back into animal feed, while the harvesting system reduced ammonia and odor emission. By recycling excreted minerals including phosphorus into animal feeds it is possible to eliminate the need for land application of phosphorus-rich waste. Also, considering presently used waste disposal practices, this system is expected to be economically competitive with land-application at agronomic rates.

Key Theme: Diversified/Alternative Agriculture

a. Issue: North Carolina farmers are searching for new sources of farm income and for ways to diversify their operations, and to develop sound and cost-effective environmental practices to stay competitive. To support the emerging goat industry, research began on the evaluation of adaptable forages and fodder trees suitable for meat goats and on the use of locally-available byproduct feeds for goats fed forage-based diets. Additional research is exploring non-pharmaceutical approaches to treating goats against gastrointestinal parasites.

b. Impact: Interest in meat goat production as a new business opportunity has increased dramatically during the past six years because of the increased demand for goat meat by a growing segment of the population of North Carolina and the southeastern United States which represents ethnic groups who prefer goat meat in their diet. Producers in NC sold about 232,000 goats for meat in 2003, generating receipts of over $9.7 million dollars.

c. Scope of Impact - State specific

National Goal 2: A SAFE AND SECURE FOOD AND FIBER SYSTEM

Food and Fiber Processing, Safety and Quality

Overview

The well being of the United States and its citizens depend on a safe and secure food and fiber production and delivery system. Therefore, protecting the stream of resources from the farm and forest to processors and distributors, and ultimately to consumers, is of utmost priority. Whether the threat may come from poor sanitation during harvest, processing, or preparation or from synthetic or natural toxicant residues, objective, science-based research is necessary to provide producers, suppliers, and consumers with the best management and decision making tools and techniques possible to prevent illness and disease. Consumers want a safe and plentiful supply of high quality food and fiber. More foreign-produced food and fiber products are coming to the United States than ever before, with associated concerns about safety and quality. Consumer concern with *Escherichia coli*, *Listeria monocytogenes* and other potentially life threatening microbiological contaminants as well as pesticides, hormones, and other toxicants require redoubled efforts to guarantee a safe and worry-free supply of wholesome food.

To address all aspects of safety and quality in the food and fiber system, research must be carried out at the production level, the harvest and marketing level, the processing level and the preparation level. Additionally, with the diverse production system found in North Carolina, the research must be conducted over a broad spectrum of commodities and situations. The performance goals for this program area are primarily focused on identifying problems and solutions to quality maintenance in storing and marketing fruits and vegetables, field crops and animal products; ensuring that food products are free from toxic contaminants; and protecting food and feed supplies from harmful microorganisms and naturally occurring toxins.

Performance goal 1, which seeks to identify problems and solutions for quality maintenance in storing and marketing fruits and vegetables, field crops and animal products, has been addressed in the following ways:

- Control defenses are being developed to combat the antibiotic resistant strains of *Campylobacter and other pathogens* found in food production systems to help prevent the leading cause of human gastroenteritis.

- Studies have evaluated mechanically separated poultry meat, which has relatively low value and limited application due to high content of fat, bone and/or collagen. A process has been developed to produce a meat protein isolate virtually free of these contaminants. The isolates can then be injected into intact muscle, markedly increasing water retention and leading to firmer texture of the cooked product.
- Technologies have been developed to validate the process of a continuous-flow thermal particulate-laden, low-acid food product. This technique paves the way for conversion of millions of pounds of canned product into aseptically processed products, especially those commercial applications desiring units larger than the #10 can.

Performance goal 2, which ensures that food products are free from toxic contaminants, has been addressed by studies determining the performance (accuracy and precision) of five commercial kits to measure peanut protein (allergens) in four different food products. These estimates will help the U.S. Food and Drug Administration reduce uncertainty and make correct decisions concerning the unintentional contamination of foods with allergenic peanut protein.

Performance goal 3, addresses protecting food and feed supplies from harmful microorganisms and naturally occurring toxins.

- Studies assessed near real-time methods for detecting food-borne pathogens without sacrificing detection limits. These methods employ non-specific bacterial concentration followed by specific detection and endpoint confirmation using nucleic acid amplification-based strategies.
- Studies of risk assessment technologies are aiding the understanding of the role of foods in the transmission of antibiotic resistant strains of *Enterococcus* to human populations whereas others are identifying and understanding the unique characteristic of strains of *Listeria* implicated in human illness. This type of knowledge will improve our ability to evaluate potential threats posed by contamination of food by these organisms.
- A study showed that relatively high numbers of bacteria may be transferred to ready-to-eat foodstuffs even 1 to 2 hours after surface contamination in the food preparation areas. In order to reduce the risk of transfer of foodborne pathogens to ready-to-eat foodstuffs, continuous disinfection practices are needed.
- As global competition in fishery industries has grown, so has the need for rapid, accurate quality and safety monitoring systems. Spectral sensing methods have been developed to successfully identify species and product adulteration within samples.

FTEs & Program Cost for Goal 2
Program cost is inclusive of federal Hatch funds appropriations, other federal contracts and grants, state appropriations, and other contracts and grant funds.

Federal App.	State App.	Fed G & C	Non Fed Grants	SY	PY	TY	CY
$310,082.78	$2,295,689.33	$319,899.50	$333,383.10	11.72	18.91	20.92	3.22

Key Theme – Food Quality

a. Issue: The use of time-temperature integrators (TTIs) to continuously monitor food product temperature may facilitate the strict temperature control required to effectively optimize the product's shelf life. Research findings demonstrated that enzyme-based TTIs could be used in chicken drumsticks to predict the population of spoilage microorganisms, end of shelf life and remaining drumstick shelf life under both constant and variable refrigerated storage conditions reflecting ideal and abusive temperature situations. Studies also demonstrated that color changes in the TTI biosensor can be accurately and objectively monitored using simple analytical tools.

b. Impact: This technology will provide valuable storage temperature abuse information for the processor and retailer and will provide a basis for an effective stock rotation plan that saves money for the retailer and consumer. Moreover, the application of TTIs to food products may improve the safety of food products by identifying temperature abuse situations that result in the growth of foodborne pathogens on fresh, perishable food products.

c. Scope of Impact - National

Key Theme – HACCP

a. Issue: Histamine or scombroid fish poisoning is one of the most common chemically induced seafood borne illnesses reported in the U.S. The illness causes symptoms similar to that of an allergic reaction in humans. The cause is biogenic compounds produced in fish due to growth of gram-negative spoilage bacteria. A study has been completed that observed time and temperature conditions in commercial operations for mahi-mahi (dolphin fish) and yellowfin tuna in North Carolina. The results of this study demonstrated industry's compliance with temperature requirements under the current HACCP requirements. We also found histamine levels in fish below FDA's defect action levels of 50 ppm. However, environmental sampling of fish and the surfaces that fish came in contact with were found to contain histamine producing bacteria.

b. Impact: The results of this study will empower consumers to make more informed decisions about their seafood purchases and it will provide financial incentives to commercial operators for improving handling and distribution systems for their catch. Moreover, the economic benefits will be realized in higher quality and safer fishery products on the market and reduced health costs due to a reduction in the incidence of histamine fish poisonings.

c. Scope of Impact - State and National

Key Theme – Food Resource Management

a. Issue: There is a danger looming in the world of bio-processing, where micro-organisims are relied upon daily to transform milk into cheese and yogurt, turn grape juice to wine, and produce many valued biologics, such as vaccines and enzymes. Small viruses, called bacteriophages, often contaminate these processes and infect the starter culture used to carry out the fermentation or bioprocess. Once infected, the bacterial virus replicates - eventually causing the bacterium to burst open and release hundreds of new phages into the bioreactor. These new viruses go on to infect more and more bacteria until all are dead and the bioprocess halted. Using recombinant DNA techniques, we introduced small mutations into primase protein to inactivate the replication function, but not alter

the domain responsible for subunit association. We found that virus multiplication can be completely halted by "subunit poisoning" of this essential enzyme that replicates the phage's genome.

b. Impact: Yogurt sales in the U.S. alone in 2003 are estimated at over 3 billion dollars, growing at a rate of 10% over 2002. Milk and yogurt fermentations are not sterile and repeated use of these starter strains in large cheese and milk plants, with processing volumes approaching 2 million liters per day, provide ample opportunity for recurring phage infections. Our results establish a model bio-processing protection system that could be implemented in any bioprocess that is susceptible to bacteriophage attack, and is amenable to use of GMO's.

c. Scope of Impact - National

Key Theme – Foodborne Pathogen Protection

a. Issue: Food-borne human illness and antimicrobial resistance in bacteria continue to play major roles in the national human health arena. Poultry integrators now accept the roles that they must play in securing food safety. Specifically, the need to determine the role of antimicrobial use in poultry husbandry and how that use relates to human diseases caused by organisms resistant to antimicrobials is essential. Our work monitoring turkey flocks for *Campylobacter* species is a first in turkeys. The current debates among regulatory officials assume that turkeys are just large chickens. Our preliminary work indicates that this is not true. Contamination levels are quite variable in turkeys, the *Campylobacter* species present are variable, and the anti-microbial resistance patterns are variable.

b. Impact: The turkey industry will be able to establish guidelines for on-farm initiatives that determine the role anti-microbial agents have on resistant strains of microbes in humans.

c. Scope of Impact - National

National Goal 3: A HEALTHY, WELL-NOURISHED POPULATION

Human Nutrition and Human Health

Overview

A healthy, well-nourished population is productive and effectively contributes to a vital and improved society. Although the supply of food resources in the United States is among the most

abundant in the world, there are segments of the population who live in poverty and are under-nourished. These circumstances, combined with the problems of inadequate access and delivery of health care place many Americans in a difficult and undesirable standard of living. Still others, who have access to abundant food and health care, often do not have the knowledge and training to make informed decisions about proper diet and exercise to promote a healthful lifestyle. In addition, rapid and accurate disease detection and prevention are necessary components for contributing to healthy individuals and a healthy population.

Insects and related arthropods directly impact quality of life as vectors of major diseases of humans, their pets and domestic livestock and poultry. They further serve as serious pests through direct feeding on humans and animals. Finally, these pests are nuisances and reduce property values by destroying the buildings we live in. Each of these aspects results in serious economic losses to our state and the nation as well as reducing the quality of life enjoyed by citizens. Therefore, objective, science-based research is necessary to provide citizens, educators, and others with the best information and decision making tools possible to ensure a healthy population.

To address relevant aspects of human nutrition and human health, research must be carried out in various areas including disease prevention and health promotion, nutrient availability and absorption associated with food choices, habits, and consumption, the linkages between nutrition and disease prevention, and the improvement of the quality of life. The performance goals for this program area are primarily focused on the level of adoption of human health practices and hazard reduction, centering on food choices, habits and consumption; food safety issues as related to overall consumer health and well-being; and developing methods for mitigating impacts of insects and related arthropods as vectors of human and animal diseases, as direct pests of humans and their domestic animals and livestock, and as pests of human habitations and institutional buildings.

Performance goal 1, which seeks adoption of human health and hazard reduction strategies centering on food choices, habits and consumption, has been addressed by studies of alternative processes to immersion frying and heat processing technologies.

- Technology is being developed using radiant heating utilizing electromagnetic energy. This technology may be used to replace immersion frying which will substantially reduce the oil content and fat calories associated with fried foods.
- Through selected heat processing technologies, the antioxidant content of many berry juices has been maintained while retaining flavor and juice quality. Blended juices show superior quality and antioxidant content compared to commercial juices and provide needed antioxidant-rich raw material from several surplus North Carolina commodities.

Performance goal 2 addresses the issues of food safety as well as relation to overall consumer health and well-being. Investigations in this area include the following:

- A fungicide program for the control of apple diseases for apples grown for use in production of baby food was developed. This program minimizes/eliminates residues of fungicides that are classified by the U.S. Environmental Protection Agency as B2 carcinogens on apples.
- Researchers at NC State University, Duke University and Northwestern University are utilizing egg-laying chickens to evaluate two chemopreventive agents (levonorgesterol, as used in birth control pills, and a new drug, 4-HPR, developed at the National Cancer institute) for their potential to reduce the incidence of ovarian cancer. The chicken model is supporting

the development of acceptable preventive programs and provides a more rapid evaluation mechanism for new preventive therapies for human ovarian cancer. The avian model allows for chemo-prevention screening at an accelerated rate (2 years versus 5-7 years to screen in women) at a greatly reduced cost to society. Chemo-prevention studies in women cost an estimated $50 million, compared to $500,000 in birds.

- Researchers have also developed a new theory and practical framework for design and analysis that will allow valid statistical comparison of several complex strategies. This work may be useful in comparing complicated strategies for the treatment of HIV disease that involve cycling patients on and off multiple therapies based on indicators of their past and current treatment and state of health.
- Toxic forms of oxygen have been implicated in human diseases and syndromes including cancer and aging. Scientists have determined that vitamin B6, an essential vitamin that was not previously known to be involved in protecting cells, can protect against toxic oxygen damage. Understanding how living cells defend themselves against these forms of oxygen will aid in devising control strategies for diseases.
- Research has found that while older adults recognize the risks from smoking, they usually assume that there remains time to quit and avoid serious health impacts such as lung disease, cancer, heart attacks, congestive heart failure and stroke. Smokers seem to believe death would be a smooth transition and did not understand the quality of life effects of serious smoking-related diseases. Evaluation of a new message indicated that it was effective in inducing smokers to alter their beliefs about the health risks of continued smoking.
- In a study of the genetic makeup of *Drosophila melanogaster,* four polymorphic markers were identified that are significantly associated with life span and five with starvation resistance. The genes of the catecholamine pathway are potentially important candidate genes for diseases of aging and metabolism in higher animals. An understanding of the association between molecular variation at these loci and phenotypic variation in life span and starvation resistance will increase our understanding of the genetic basis of variation in complex traits. This study is a stepping-stone to mapping genes affecting age-related human diseases such as Alzheimer's and Parkinson's diseases.
- The isolation, biochemical characterization and structural analysis of *P. furiosus* prolidase have provided valuable information regarding the potential use of this enzyme to degrade toxic organophosphorus nerve agents such as soman and sarin. Ultimately, the biochemical and structural data can be used to modify *P. furiosus* prolidase to improve its activity and stability for use in organophosphorus nerve agent detoxification.
- Research focusing on auto-immune disease has identified a key molecule whose activity is necessary for the tissue damage normally associated with these diseases.
- A vaccine has been produced that provides swine with resistance to the porcine reproductive and respiratory syndrome (PRRS) virus. The molecule identified as important for autoimmune disease could be used as a target for pharmaceutical development.
- A protein called $cPLA_2$, which is central to the inflammatory process, has been identified. Regulatory signals involved in activating this enzyme and beginning the inflammatory response are being studied. The results of this project have the potential to impact the health and well being of society by providing the foundation for the development of therapeutic strategies to combat inflammation.

Performance goal 3, which attempts to develop methods for mitigating impacts of insects and related arthropods as vectors of human and animal diseases, as direct pests of humans and their domestic

animals and livestock, and as pests of human habitations and institutional buildings, has been focused on by the following research:

- Intervention trials were conducted in 16 homes that consisted of occupant education, placement of insecticide bait and professional cleaning. Allergen levels were reduced below the sensitization threshold in beds, arguably the most relevant site for exposure, and below the asthma morbidity threshold on bedroom floors and living room floors/sofas.
- A socio-economic study of La Crosse encephalitis was completed. The socioeconomic burden resulting from this disease is substantial and highlights the importance of the illness in disease endemic areas of North Carolina as well as the need for active surveillance and prevention programs for the vector/virus complex.
- A new strategy was developed to produce a vaccine for West Nile Fever. This strategy is based on the development of mutations that restrict growth to the insect host.
- New and detailed information about the structure and mechanics of the ribosome was developed that will be of significant value in the design and search for new ribosome-targeting antibiotics.
- Using molecular genetic markers to map the locations of termite colonies infesting and surrounding homes in central North Carolina, researchers found that many homes had numerous colonies within 50 feet of the foundation and may have up to three colonies actively infesting a house simultaneously. These studies showed that termite treatments limited to a small area of a structure may not effectively protect it against attack by subterranean termites.

FTEs & Program Cost for Goal 3
Program cost is inclusive of federal Hatch funds appropriations, other federal contracts and grants, state appropriations, and other contracts and grant funds.

Federal App.	State App.	Fed G & C	Non Fed Grants	SY	PY	TY	CY
$238,511.95	$672,299.75	$408,171.60	$106.881.50	4.1	7.58	7.7	1.16

Key Theme: Human Health

a. Issue: La Crosse encephalitis (LACE), caused by a mosquito-transmitted virus, is a leading cause of pediatric encephalitis in the U.S., with North Carolina reporting more LACE than adjacent states. In North Carolina, the disease is restricted to the mountains, especially the Cherokee Indian Reservation, where large populations of the mosquito vector, *Ochlerotatus triseriatus*, occur. This study, the most comprehensive analysis of the socioeconomic impacts of LACE in the United States, revealed that the health burden resulting from the disease is substantial.

b. Impact: Direct and indirect medical costs of a single case were $32,974. For those suffering from lifetime recurrent seizures as a result of LACE, direct medical costs ranged from $48,775 to $3.2 million. In addition, LACE victims will lose an estimated 12 percent of productive life years. The primary stress factor for LACE patients and their families was lack of information, both during (76 percent) and after (56 percent) the acute phase of the disease. This study highlights the need for active surveillance and prevention programs in this part of the state.

c. Scope of Impact – State Specific

Key Theme: Human Health

a. Issue: Because ovarian cancer is difficult to detect, it is generally diagnosed in advanced stages and only 35% of ovarian cancer patients are cured. With 16,000 to 17,000 women dying in the U.S. from this disease annually, screening chemo-preventive compounds more rapidly would result in more lives saved. We developed an avian model that allows for chemo-prevention screening at an accelerated rate (2 years) at a cost to society that is greatly reduced. Our research has successfully screened three compounds and currently completing tests on an additional two.

b. Impact: We found that two of the three compounds were not effective in birds, at a research cost of $300,000. This finding would have cost $100 million and taken 5-7 years to complete had they been screened in women. This research utilizing an avian model to screen chemo-preventive compounds has the potential to saves the lives of women at risk for ovarian cancer and save millions of dollars in research and health care expenses.

c. Scope of Impact –National

Key Theme: Human Health

a. Issue: Infertility is one of the biggest health concerns of the health community, with approximately 70% of the cases of infertility among couples in the US attributed to male reproductive failure.

b. Impact: We have demonstrated the importance of transmitting abnormal epigenetic information to future generations, with subsequent morphological defects and problems with fertility. This has a highly significant impact on the understanding of how xenobiotic exposures in an individual can potential affect future generations and how this may make these future generations more susceptible to xenobiotic exposures and other insults.

c. Scope of Impact - National

Key Theme: Human Health

a. Issue: The detoxification and metabolism pathways of the liver provide protection from the continuous insult of natural and synthetic compounds, but these pathways may also cause bioactivation of compounds to toxic metabolites. We are investigating the hormonal regulation of steroid and xenobiotic receptor (SXR), also known as pregnane X receptor (PXR), which may be the rate-limiting determinant of metabolizing enzyme induction.

b. Impact: These findings will help elucidate the mechanisms by which environmental contaminants cause liver toxicity, endocrine disruption, or cancer.

c. Scope of Impact - National

Key Theme: Human Health

a. Issue: With the recent rise in terrorist activities world-wide and the current engagement of the United States Armed Forces in various conflicts, the possibility that people could be exposed to toxic organophosphorus (OP) nerve agents such as soman and sarin has become a great concern. Currently, decontamination of OP nerve agent-exposed sites and equipment involves treatment with decontamination solution #2 (DS2) or bleach. Although such treatment effectively degrades the OP compounds, both DS2 and bleach are highly corrosive, resulting in damage to both the treated surfaces and the production of hazardous waste, which must be then be removed. These complications have spurred interest in developing alternate approaches for the decontamination of OP-exposed sites. One alternate approach that has particular appeal is the use of enzymes to degrade OP compounds, a method that would not be corrosive and would not generate further hazardous waste.

b. Impact: Recently the enzyme prolidase from the hyperthermophilic (optimum growth temperature >80 °C) microbe *Pyrococcus furiosus* has been isolated and purified. *P. furiosus* prolidase normally functions in the cell as a dipeptidase that cleaves proline residues present in the C-terminal position of dipeptides, however, prolidase has also been shown to cleave the oxygen-phosphorus bonds present in OP nerve agents, rendering them nontoxic. In an effort to understand the mechanism used by this enzyme to break O-P bonds, the structure of *P. furiosus* prolidase was solved using X-ray crystallography. Based on the structural information for *P. furiosus* prolidase, studies are being conducted to modify the enzyme to optimize its use for the detoxification of OP nerve agents. The isolation, biochemical characterization and structural analysis of *P. furiosus* prolidase have provided valuable information regarding the potential use of this enzyme to degrade toxic OP nerve agents. Ultimately the biochemical and structural data can be used to modify *P. furiosus* prolidase to improve its activity and stability for use in OP nerve agent detoxification.

c. Scope of Impact - National

Key Theme: Human Health

a. Issue: Each of the 5 million lymphocytes humans generate daily expresses an antigen receptor from uniquely rearranged genes. This process of gene rearrangement, termed V(D)J recombination, is a striking example of developmental gene regulation in which a committed stem cell remodels its genetic makeup. However, the mechanisms that target individual gene segments for rearrangement are unclear.

Impact: A novel system for dissecting the molecular mechanisms underlying differential gene segment recombination has been developed. This system includes separate B and T lymphocyte cell lines which will express recombinase proteins upon alteration of culture conditions, generation of a novel DNA recombination substrate, isolation of the mouse Dβ2 transcriptional promoter, and development of chromatin immunoprecipitation assays that allow us to measure recombinase protein binding at individual gene segments. The inability to complete recombination impairs lymphocyte development leading to immunodeficiencies of varying severity. Conversely, inappropriate targeting of recombination can result in chromosomal translocations that lead to lymphoid malignancies. Our research will provide a molecular framework for understanding the strict ordering of antigen receptor gene assembly. Given the involvement of multiple transcription control elements in V(D)J recombination, the proposed studies additionally promise more global insights into the general developmental mechanisms that underlie tissue-specific gene activation.

c. Scope of Impact - National and International

National Goal 4: AN AGRICULTURAL SYSTEM WHICH PROTECTS NATURAL RESOURCES AND THE ENVIRONMENT

Overview

Agricultural producers, agribusiness professionals, public officials, agency personnel, special interest groups, and the general public are all concerned about environmental quality in North Carolina. Goal 4 focuses on efforts to enhance cooperative and collaborative efforts to protect the environment and preserve natural resources while promoting a strong and diverse agriculture.

The research activities associated with Goal 4 are aimed at enhancing our understanding of the physical, biological and chemical processes and interactions influencing agricultural and forest ecosystem impact. Interdisciplinary research projects will advance knowledge of natural processes to enable development of production management and environmental protection technologies that will increase productivity; improve input efficiency; conserve natural resources; and improve and protect environmental quality. Other research activities conducted under Goal 4 have concentrated on understanding relationships between soil fertility and plant communities; identifying biological and physio-chemical factors that influence establishment and growth of trees; developing improved understanding of the habitat factors that influence reproduction and survival of terrestrial wildlife; and identifying environmental factors that influence the reproduction, recruitment and survival of fish. Some of the research efforts and outcomes under Goal 4 follow.

- The Animal and Poultry Waste Management Center was established to address waste management issues, to find ways to ensure the vitality of the state's important animal and poultry production industries, worth nearly $4 billion annually, while also protecting the environment.
- Advanced x-ray techniques have been used to show that a gypsum (calcium sulfate) amendment promoted the formation of lead sulfide in a wetland impacted by lead mining wastes. These and other treatments affected the bioavailability of toxic metals in the wastes, and this research led to a remediation approach that restored the barren wasteland to a well-vegetated, functioning wetland ecosystem.
- An evaluation of 48 sea oat (*Uniola paniculata*) accessions of diverse geographical origin was conducted at Wrightsville Beach. Vigorous, persistent and fertile accessions are being selected for utilization in coastal dune stabilization.
- Research indicates that removing fiber content from animal feed can reduce nitrogen and organic waste production. Corn was processed to remove hulls and germ, both high-fiber components, leaving the endosperm as a feed ingredient for pigs. Findings included a reduction in waste production of approximately 40%, a reduction of odor emission, and no negative effects on animal performance.
- Preliminary laboratory analyses suggest that cotton stalks that contain approximately 10% moisture, 25% lignin, and 60% carbohydrate, are good candidates for bioethanol production through proper pretreatment, hydrolysis and fermentation. This research offers potential for

renewable energy generation while also removing a crop residue that contributes to cotton boll weevil infestation.

- A real-time-remote-monitoring, automated platform system to intensively monitor and research water quality and aquatic ecosystem health was developed and installed in the Neuse Estuary. The data from the automated platform system are accessed by more than one million people per year and are used by the State's environmental/health agencies as an "early warning" system to detect environmental conditions that may promote massive fish mortalities.
- The factors controlling pollutant movement from soils to waters have been defined. This information has allowed the design of best management practices for minimizing pollution resulting from agricultural practices. For example, essentially all of the Neuse Agricultural Rules adopted by the State are based on these research results.
- A belt system was evaluated for harvesting swine excreta. This system was designed such that urine and feces are passively separated, resulting in a dry fecal stream. Swine housing equipped with belts results in 75% less ammonia emission, substantially lower odor emission, and waste streams that are more flexible in their use.
- Reduced water consumption and improved product safety are being achieved through improved carcass washing systems at poultry slaughter facilities.
- Ground penetrating radar is being used to indicate areas that may be problematic for wetland restoration due to piercing of clayey aquitard layers by drainage ditches. The remote sensing techniques developed in this project will improve our ability to choose appropriate sites for wetland restoration, utilize appropriate methods to achieve that restoration, and monitor restoration progress.
- A system has been evaluated to recover ammonia from swine urine. This system has the ability to convert this ammonia in ammonium sulfate, a commercial-grade fertilizer.
- An under the row pre-plant application method for phosphorus fertilizer for Christmas trees has been developed and is being tested at two experiment stations and at nine on-farm locations in western North Carolina. If this method works as well as expected, it will drastically reduce phosphorus fertilizer application rates.
- Research showed that parallel subsurface drains placed relatively shallow and close together, tend to reduce drain flow, nitrate nitrogen (NO3-N) in shallow groundwater, and NO3-N loss in drainage water, compared to deeper drains with wider spacings. These findings could make it possible to reduce N losses from drained lands to surface waters and associated negative environmental impacts, without reductions in crop yields.
- Research which has been conducted to quantify the effects of shading from highway bridges on plant growth and productivity of tidal marshes indicates that bridge height and width affected the light available for plant growth. These results can be used to encourage design and construction of bridges that have little or no impact on productivity of underlying tidal marshes.
- The DRAINMOD-N II model was developed to predict the effects of drainage system design and management on N losses in surface and subsurface drainage waters for different soils and climatological conditions.
- An advanced x-ray technique was used to understand how rainbow trout assimilate in their livers potentially-toxic zinc from contaminated sediments. It was shown that zinc is bonded to sulfur (apparently in metallothionein proteins) in the liver, which effectively prevents the zinc from being toxic to the fish at moderate body loads.

- In order to rebuild or establish new wetlands, a large scale project of the Juniper Bay wetland restoration project will help reduce the cost of wetland mitigation by improving both the selection of candidate sites and the methods used for modifying hydrology in the attempt to establish wetland conditions.
- Riparian buffer research at two locations demonstrated the importance of the interaction between the soil system and hydrology. High rates of subsurface nitrate reduction were determined at one location where shallow groundwater depths were no greater than four feet; medium rates were found where groundwater depths were seven to eight feet.
- Techniques to reduce pollution by reducing the salt required for fermentation of vegetable products are being developed by better understanding the complex bacteriophage ecology interacting with bacteria, which carry out the fermentations.
- Research on the abundance and distribution of salamanders in the Great Smoky Mountains National Park has shown that current sampling methodologies will need to be improved, if long-term trends in global amphibian numbers are to continue to be used as a means of monitoring environmental quality.
- Scientists are looking at the effects of controlled burns on seed production of rare plant species. This information will be critical in future management of rare species in Coastal Plain habitats.
- Research on mortality from hooking and decompression shows that survival of groupers is enhanced by use of circle hooks to reduce gut hooking and bycatch rates and that fishing for grouper at nearshore (shallower spots) will reduce the number of dead undersize fish resulting from damage resulting from decompression.
- The study of the biodiversity and biogeography of wood decay fungi in the Aphyllophorales in North Carolina has resulted in the collecting or recording of more than 4400 taxa, their location and host plants.
- Research at the Savannah Rive Site on the role of corridors in dispersal of plants and animals is producing results that will enable the design of the geometry, size and other characteristics that must be maintained for corridors to be effective as a means of maintaining biodiversity.
- Research on the natural history and population dynamics of flathead catfish has enabled the development of better management plans for its control.

FTEs & Program Cost for Goal 4
Program cost is inclusive of federal Hatch funds appropriations, other federal contracts and grants, state appropriations, and other contracts and grant funds.

Federal App.	State App.	Fed G & C	Non Fed Grants	SY	PY	TY	CY
$891,620.00	$5,512,431.16	$1,024,468.85	$637,667.05	29.43	40.46	49.8	7.44

Key Theme: Sustainable Agriculture

a. Issue: The purpose of a cooperative research project is to develop and evaluate an innovative swine waste management system that integrates anaerobic digestion and greenhouse vegetable production at a private cooperating farm. This integrated swine waste management system recovers energy in the form of electricity and heat and nutrients through greenhouse vegetable production. Anaerobic digestion produces biogas which is utilized to generate electricity. Nutrients in the anaerobic effluent and waste heat and carbon dioxide (CO_2) from the electricity generation can be utilized in the greenhouses for vegetable production. Trickling biofilters were installed for biological nitrification to convert ammonium in the effluent of the anaerobic digester to nitrate. The nitrified water is then used to recharge the pits in the pig houses.

b. Impact: Anaerobic digestion of swine manure and utilization of biogas for electricity and heat production limits methane emission to the atmosphere. Methane is believed to contribute to the global warming, as well as having the properties to generate green energy. Using effluent from the anaerobic digester as a fertilizer for high value crops such as tomato has economic benefits for growers and will positively impact the environment by reducing the amount of waste material that is released. Air quality inside the pig houses has been significantly improved as well as drain pipe clogging problems caused by struvite being greatly alleviated since the nitrification biofilters were installed and the nitrified water was used to recharge the pits. This project of one of the alternative swine waste management systems funded by the Agreement between NC Attorney General**'s** Office and Smithfield Foods Corporation/Premium Standard Farms. Preliminary evaluation results indicate that the integrated swine waste management system at Barham Farm is very promising in meeting the requirements of "Environmentally Superior Technology" defined by the Agreement. A bioremediation system in which treated animal wastewater is used as an input for plants is particularly attractive because it at least partially recovers the value of the nutrients.

c. Scope of Impact - State Specific

Key Theme: Agricultural Waste Management

a. Issue: Nitrogen mineralization rates under laboratory conditions were measured for sludge from lagoons of nine different swine operations (farrowing, nursery and finishing operations for three different companies). Mineralization rates for organic N in all sludge sources were similar. On average, 41 % of the organic N in the sludge mineralized during the 3-month incubation period under aerobic conditions. Currently, NCDA&CS uses one plant N availability coefficient for all types of lagoon sludge in calculating plant available N in sludge samples. The absence of significant company or type of swine operation effects on sludge N mineralization suggests that the same plant N availability coefficient for sludge from different types of lagoons is justified provided other components in the sludge do not influence N uptake by the receiver crop.

b. Impact: This information has value for both industry and regulatory agencies in making decisions about how to manage sludge in an environmentally sound and cost effective manner as lagoons age or as lagoons are phased out as the primary waste management system in the swine industry.

c. Scope of Impact - State Specific

Key Theme: Agricultural Waste Management

a. Issue: Engineers at North Carolina State University developed a procedure to collect gas emissions from the surface of waste treatment systems with minimal atmospheric contamination and have quantified the amount of dinitrogen that could enter the collection and analysis system from the atmosphere and from stripping dissolved dinitrogen from the liquid. This physical evidence is being corroborated with microbiological evidence of the presence of the microorganisms responsible for ammonia oxidation, the first step in the nitrification – denitrification process.

b. Impact: Although work continues in these areas, the evidence so far shows that ammonia volatilization from animal waste lagoons may not be as much of a problem as previously thought. This would reduce the pressure to replace all such systems and relieve some of the economic burden facing the animal industry.

c. Scope of Impact - State Specific

Key Theme : Air Quality

a. Issue: A number of state-of-the-art techniques for measuring ammonia emissions from housing units and water-holding structures have been combined to assess the reduction in ammonia emissions possible when proposed environmentally superior technologies are deployed at swine production facilities. To date, over 10 technologies have been evaluated during two seasons of the year (summer and winter) and the resulting emissions incorporated into a strategy to allow differentiation of reduction in ammonia emissions as compared to a standard Lagoon and Spray System while still accounting for variables such as local and seasonal weather patterns and differences in animal populations and ages of animals. A series of reports have been provided to the Animal and Poultry Waste Management Center, NC State University, Raleigh, NC, which is charged by the North Carolina Attorney General's office to conduct the evaluations. This information will be combined with data regarding pathogen reduction, reductions in odor and odorants, and economic analyses to derive a basis for evaluation/ranking of the 18 proposed Environmentally Superior Technologies for swine production in North Carolina. All evaluations are to be completed by January 1, 2005.

b. Impact: Modern large-scale animal production facilities represent multiple sources of potential emissions of ammonia, odors and pathogens that can negatively impact environmental and human health. This project employs state-of–the–art scientific techniques in a coordinated effort to assess emissions from proposed alternative Environmentally Superior Technologies for swine production in North Carolina. This coordinated effort will fulfill the promise of producing an integrated assessment for each EST, while also affording the opportunity to further our understanding of previously unrecognized interactions among the many variables that influence emissions from large-scale animal production facilities.

c. Scope of Impact - State Specific

Key Theme: Water Quality

a. Issue: Extensive remote water quality monitoring and research on the Neuse River and Estuary is focused on providing real-time, web-based data for research, education/outreach, and resource management applications. This valuable data source is used by the state's environmental agency to monitor and assist in assigning causality to major fish kills. The data have also strengthened the state's early warning system to help protect the health of people who use the Neuse. The information has been used to help educate the citizenry and calm fears about fish kills, thereby strengthening tourism, seafood, development and other industries, and the overall economy of eastern North Carolina. The advanced remote sensing technologies of our automated platform system also have improved scientists' ability to evaluate nutrient and other pollutant inputs from watershed land use practices. The powerful database generated by this remote monitoring system has been made available to all stakeholders in water quality issues on the Neuse.

b. Impact: This effort resulted in a recently developed partnership with industry to develop water quality testing equipment that will benefit many state, federal, private, and academic laboratories worldwide. In 2003, YSI Corporation entered into a marketing venture with CAAE and NCSU office of Technology Transfer to the manufacture and sale our patented Real-Time Remote Monitoring System, with substantial revenues expected.

c. Scope of Impact - State and national

Key Theme: Water Quality

a. Issue: Research at NCSU has shown that the current method of assessing soil wetness overestimates the depth to seasonal wetness. Seasonal wetness is a major cause of on-site wastewater treatment system (septic) failure. Thus the overestimation of its depth results in systems being installed too deep in the soil and being subjected to premature failure.

b. Impact: By locating and installing systems shallower in the soil based on revised soil criteria, owners may save the cost of repairing or replacing a failing system. Currently, approximately $70 million (30% of the total 250 million dollars for the industry as a whole) is spent annually on repairing failed systems. Proper siting of systems based on more conservative soil criteria could save North Carolinians upwards of $35 million as well as alleviate an environmental and public health risk.

c. Scope of Impact - State Specific

Key Theme: Water Quality

a. Issue**:** Gasoline oxygenates such as methyl *tertiary* butyl ether (MTBE) and *tertiary* butyl alcohol (TBA) are widely used to improve the combustion efficiency of automobile engines and are designed to reduce emissions of smog-forming products. The air quality benefits that have been obtained using oxygenates has, to a large extent, been offset by the deleterious impacts of these compounds on ground water sources of human drinking water. These impacts on ground water have arisen primarily from leaking underground storage tanks at retail gasoline stations. The large number of oxygenate-impacted sites around the US requires that cost-effective remediation methods are developed for

these compounds. Our research investigates the potential use of microorganisms in the biological remediation (bioremediation) of oxygenates.

b. Impact: Our research has identified a number of different bacteria that can fortuitously degrade MTBE and TBA through the activities of enzyme systems that allow these microorganisms to grow on other common components of gasoline. Our research has also identified the pathway of oxygenate degradation in several diverse organisms and our current research is focused on the molecular characterization of the enzymes responsible for this activity. In combination, these studies are expected to translate into field-applicable tools that will provide unequivocal evidence for the role of microorganisms in the environmental fate of oxygenates and molecular probes that can be used to determine whether the potential for oxygenate biodegradation exists in gasoline-impacted environments.

The economic impact of oxygenate contamination of ground water is measured in the billions rather than millions of dollars. For example, the State of New Hampshire recently sued oxygenate manufacturers and distributors for in excess of $20 billion to cover the clean up costs in this sparsely populated state. Similar costs are expected in the other major MTBE-using states centered on the I-95 and I-5 corridors. These costs are also likely to be transferred from industry to the States if the "MTBE-waiver" included in the current Energy Bill comes into law. As bioremediation is likely to be the most cost-effective methods for oxygenate remediation the impact of research directed at understanding and promoting biological degradation of these compounds has enormous potential economic impacts both locally and nationally.

c. Scope of Impact - State and National

Key Theme: Water Quality

a. Issue: With the current emphasis on using riparian and vegetative buffers to help reduce off-site surface water quality problems, researchers are developing engineering design tools to help water quality agencies optimize buffer size with water quality benefits. Researchers at North Carolina State University, with USDA support, have developed engineering design tools to help water quality specialists size vegetative buffers to reduce off-site movement of eroded soil. The computer model, VFSMOD, simulates the effectiveness of vegetative filter strips to trap sediment. A graphical user interface has been developed to make the model easier to use. We have also incorporated tools to enable users to assess the uncertainty of the performance of the filter strip performance along with using the model to easily evaluate multiple designs based on ranges of storm sizes and filter strip lengths. Development of additional tools to make the model easier to apply and evaluate the results is continuing.

b. Impact: Erosion continues to be a major source of non-point pollution for North Carolina's surface waters. The new version of VFSMOD enables water quality regulators to size vegetative buffers and evaluate their effectiveness reducing sediment transport to surface waters over a range of soil types. We have been allowing users to access the model via the internet. Over the past 3 years, the windows-based model has been downloaded by hundreds of users from all over the world.

c. Scope of Impact - State, National and International

Key Theme: Water Quality

a. Issue: Water Quality of both surface and ground water is a huge political and social issue in North Carolina and throughout the world. Agriculture, sometimes justifiably and frequently unjustifiably receives much of the blame for problems caused by nonpoint source pollution (e.g. sediment and nutrients). Research has provided the most accurate data available for the quantities of sediment and nutrients leaving agricultural and forested land and entering surface waters. Not only have we quantified these impacts, we have defined the factors controlling their movement from soils to waters. This has allowed us to design Best Management Practices (BMP's) to reduce nonpoint source pollution coming from agriculture.

b. Impact: Two BMPs where NC State University has generated the largest amount of scientific data available anywhere in the world are Controlled Drainage and Riparian Buffers. These practices are currently promoted world wide by regulatory agencies and environmental groups. They allow sustainable agricultural production while minimizing environmental impact.

c. Scope of Impact - State, National and International

National Goal 5: ENHANCED ECONOMIC OPPORTUNITY AND QUALITY OF LIFE FOR AMERICANS

Overview:

Rural areas, no matter how remote, have experienced massive social and economic transformations in the post-World War II era. Social and economic restructuring, the reorganization of agriculture and natural resource-based industries, de-industrialization, the shift to a service economy, and major demographic changes in population composition and processes are among the major changes. The uneven social and economic development of rural communities presents significant challenges for rural people and rural policy.

The shift of jobs away from rural communities has brought with it a set of problems related to human behavior and health. Changes in policy for key farm products, and events not under the control of North Carolina farmers, have contributed to further uncertainty and stress in rural communities. Many research results described here have helped to mitigate some of the stresses on rural communities. Others have contributed to the development of strategies for improving the economic viability of rural communities. Still others have contributed to the quality of life for Americans through contributions to improvements in health.

Research completed this year has contributed to knowledge and influenced policy in several key program components.

The following projects involved strategies individuals, families, farms and communities use to respond to global rural restructuring.

- Case studies of rural communities showed that the viability of local communities depends on the strength of local labor markets and their industrial and occupational composition.

- Results from the S276 multi-state project's national survey of U.S. adults were released on the web and other media. The findings showed that Americans hold family farms in high regard and want food that is produced locally and under environmentally safe conditions but have less trust in food produced in foreign countries.

Factors contributing to racial earnings inequalities were addressed by the following:

- A consortium for research and outreach was formalized to address the impoverishment in the Black Belt counties of North Carolina and other southern states. Currently, the consortium consists of North Carolina State University and North Carolina A&T State University. This builds upon research done on Black Belt issues at these and other southern land-grant universities.
- Using recommendations from research on the rural Black Belt South, a bill was introduced to the U.S. Senate and two bills were introduced in the House of Representatives to establish a regional commission for the Black Belt South.
- Methodologies for studying the incidence and severity of racial profiling were developed. These results were disseminated through conference presentations, policy journals, and a major report to the U.S. Department of Justice.
- A survey of North Carolina broiler industry personnel was conducted to help poultry extension personnel define the type of educational materials needed to help the industry reduce the language barrier among employees. A field manual in both the English and Spanish is under development.

The following projects involved agricultural policy related to quotas, price supports, and marketing boards.

- An economic simulation model using county-level tobacco production and quota lease rate data was developed to indicate changes in production and prices that would occur given changes in the tobacco program. The analysis answers questions such as how would production within North Carolina relocate if restrictions on quota transfer were lifted. Such information is vital in order to understand the economic impact of pending changes in tobacco policy.
- Analysis and information provided to legislative offices on tobacco buyout bills enhanced the ability of legislative staffs to design bills that would provide desired compensation to quota owners and tobacco growers and that would minimize negative impacts of eliminating the current tobacco program.
- Research that provided essential insight into the economic impact of a food safety event such as the announcement of the dairy cow in the state of Washington that tested positive for BSE in December, 2004. The research found that consumer response to such events is negative, but relatively short-lived. Overall, this research has served to temper some of the hysteria and concern in the beef industry and related industries about the potential impact on demand for their products from this event and resulted in appropriate changes in policy.

Demographic and socioeconomic factors related to rural economic development were involved in the following project.

- A survey of consumers in the Philippines documented peanut butter consumption by children, providing research that may convince peanut butter producers to fortify their peanut butter

with vitamin A, which could drastically decrease cases of blindness in children in the Philippines and other parts of the world where malnutrition is a problem, including the rural South.

Changes in the organization of local labor markets were addressed by the following project.

- An analysis of employment, migration and commuting data for the 13 Southern states showed that about 60% of new jobs in a given county are filled by non-residents of the county – either by commuters from nearby counties or by new residents moving to the county. However, while less than half of new jobs resulting from recruitment of new industries actually go to local residents, the fact that workers are so mobile means that the residents of a given county will benefit from the success of nearby counties in attracting new jobs and industries. These findings are important for local officials in rural counties and in rural communities in many other countries, as well.

FTEs & Program Cost for Goal 5
Program cost is inclusive of federal Hatch funds appropriations, other federal contracts and grants, state appropriations, and other contracts and grant funds.

Federal App.	State App.	Fed G & C	Non Fed Grants	SY	PY	TY	CY
$95,143.00	$982,382.90	$129,471.00	$144,801.70	7.11	14.24	5.15	2.05

Key Theme: Supplemental Income Strategies

a. Issue: As a result of continued reductions in tobacco quotas, dismantling of the peanut program, and the general scarcity of income opportunities in rural areas, efforts are underway across the state to add a greater diversity of opportunities for sustainability of rural communities.

b. Impact: A pilot project to construct and test market 15 crop mazes as a form of agro-tourism was conducted. Training was provided to farmers on maze design and construction of the mazes. The average number of paying customers across the sites was over 300 per site in the first year. Profit per site was as high as $5,000. The profit potential indicated by this study should result in an increase in average farm income of $5,000 to $20,000, if not too many sites are established.

c. Scope of Impact - State Specific

Key Theme: Jobs/Employment

a. Issue: Continuing demise of labor intensive manufacturing operations and employment in North Carolina is creating some urgency in state government and other economic sectors to identify and seek new sources of and incentives for employment opportunities for the state's workforce.

b. Impact: Research resulted in the development of an economic model that could be used to estimate the statewide net impact on jobs, income, and state public revenues and costs of using business incentive funds from the governor's office to attract new firms to the state. Commerce Department employees were trained in the use of this model, and its use in 15 situations resulted in seven projects being granted, which resulted in creation of an estimated 1,780 jobs and $74.7 million in investment in North Carolina.

c. Scope: State Specific

Key Theme: Consumer Management

a. Issue: Food price margin data for U.S. produced foods have been analyzed to determine the cause of the rising spread between retail and farm prices for food over time. Policymakers have been divided over what the cause of increased food price margins for food has been. Some have called for further regulation of food industries, including such things as reducing the level of vertical integration of agriculture both upstream in production and downstream in wholesaling and retailing.

b. Impact: The statistical analysis indicates that increases in demand by consumers for marketing services through food consumed away from home and demand for convenience are the main source of increase in the price spread. The effect of increases in market power by the processing and marketing industry, while statistically significant, is not economically significant and only accounts for a small portion of the rise in the price spread. Likewise, the net effect of increases in marketing input prices (labor, packaging, transport, energy) has exerted a very small increase on the marketing margin.These
results indicate that the effects of vertical integration have had little negative impact on marketing margins and therefore producer returns.

c. Scope of Impact - National

Key Theme: Youth Development/4-H

a. Issue: Restoration and protection of water quality in our state's rivers and estuaries has become a major concern of North Carolina's citizenry over the past decade. From children's summer camps on the Neuse to sailing clubs, to recreational and commercial fishermen, to our state legislators, many people have expressed the need to ensure that the water quality of our rivers and estuaries is adequately monitored to ensure public health protection. In response, a real-time-remote-monitoring, automated platform system to intensively monitor and research water quality and aquatic ecosystem health. The system is installed in the Neuse Estuary at known "hot spots" for toxic and otherwise noxious algal blooms, oxygen deficits, and fish kills, and the round-the-clock data are summarized in a freely accessible web site (www.waterquality.ncsu.edu). The web site also provides information about other water quality sampling efforts by the CAAE, for instance, along the Outer Banks.

b. Impact: The data from our automated platform system, presented on our web site in summaries that nonscientists as well as scientists can easily understand, are accessed by more than one million people per year. As examples, our State's environmental/health agencies use the information from the Neuse automated platforms as an "early warning" system to detect environmental conditions that may promote massive fish mortalities. The information is also used by children's summer camps on the Neuse to determine when water quality conditions are safe for recreational activities. The data summaries on this web site are used, as well, by visitors to our State; we frequently have been informed that the web site provided both the information they needed, and the assurance, that they could visit and safely enjoy our State's waters along the Outer Banks. Teachers from K-12 through college have informed us that our website data summaries have been used to help students understand water quality sampling, data collection, and data interpretations.

c. Scope of Impact - State Specific

B. Stakeholder Input Process

The North Carolina Agricultural Research Service (NCARS) is committed to seeking, receiving and utilizing input from all stakeholder groups, including under-represented groups and the general public. A significant portion of the input from individuals throughout the state comes from interactions of research scientists with county-based extension personnel and directly with producers, industry and other agribusiness representatives. Approximately 100 research faculty also have extension appointments. These faculty are the primary day-to-day communication link between agribusiness, county extension centers and NCARS. Because their research and extension activities are directed toward the development-implementation phase of new knowledge and technology, they are constantly relating industry needs and suggestions to other researchers whose emphasis is more in the discovery phase. In addition, these faculty interact with county extension personnel in such a way that input from individual consumers is also effectively communicated to NCARS administration and faculty.

Stakeholder input utilized in determining research directions is also received through numerous associations. NCARS interacts with 90 official commodity and agricultural industry associations from within North Carolina. A College of Agriculture and Life Sciences administrator is appointed as the official liaison for each of these associations and attends at least one, and sometimes more, of their meetings or conferences each year. During these meetings, opinions and facts related to the needs and concerns of that industry sector are obtained through both formal presentations and informal conversations with attendees. The NCARS representative is always introduced early in the meeting so that any individual there can contact them and discuss whatever issues they desire. In addition, the college has employed a Director of Commodity Relations, who reports directly to the Dean and coordinates the activities of the liaisons. This individual also has responsibility for working with any association that has a need or concern relative to the college's programs, particularly if it might involve any state or federal legislation.

Of the 90 state agricultural industry associations, 24 provide funding to various research projects annually, usually on a competitive basis. In these cases, the association board give NCARS information on high-priority research areas to be used in the request for proposals, and the board

decides which proposals to fund. This is the most targeted type of stakeholder input, having a direct effect on research activities within NCARS

NCARS leadership team interacts deliberately and frequently with leaders in the North Carolina Agricultural Foundation, N. C. Farm Bureau Federation, N. C. State Grange, North Carolina Department of Agriculture and Consumer Services, the N. C. Agribusiness Council and numerous other allied organizations that provide insight on research needs and priorities. These groups and organizations assist in program reviews, as well as advocate for the NCARS agenda by promoting the importance of agricultural and life science research.

Many of the departments within the College of Agriculture and Life Sciences have formal advisory groups with stakeholder members that meet on a regular basis to provide input and guidance into the department's research programs. There are 21 such advisory groups among the 18 research departments that meet at least once per year, and their membership includes a total of over 200 stakeholders from a wide range of agricultural interests. In addition, there are currently nine formal centers within the college with industry advisory boards that meet at least twice per year, adding another 60 stakeholders providing NCARS administrators and scientists input and direction from research programs.

NCARS receives support annually from college-based foundations, including the Agricultural Foundation, Tobacco Foundation and the Dairy Foundation. These foundations fund research projects and graduate students on a competitive basis across a wide range of areas. NCARS administration meets with the Research and Extension Committees each fall to hear discussion of priority areas for research activity in all aspects of agricultural production and agribusiness. Then in late winter, these committees meet again to select and approve research projects for funding, which provides another opportunity for input on research priorities.

Finally, because the research faculty are also major stakeholders of NCARS, there is a CALS Research Committee, which consists of one elected representative from each department. The committee meets monthly to discuss and make recommendations to the NCARS director relative to policy and resource allocations.

C. Program Review Process

There have been no significant changes in the program review processes since the NCARS 5-Year Plan of Work was submitted.

D. Evaluation of the Success of Multi and Joint Activities

North Carolina State University faculty were involved in 31 Multistate Research Projects in the Southern Region, 47 Multistate Research Projects in other regions, and 14 Southern Extension and Research Activities. These activities were all multistate, multidisciplinary and involved integration of research and extension. They continue to be an excellent vehicle for collaborative, coordinated

research and a broad-based, systematic approach to solving problems relative to the Southern Region and the nation. Examples of multistate, multidisciplinary, integrated activities other than those included above are discussed below.

The National Center for Manure and Animal Waste Management

The National Center for Manure and Animal Waste Management is a collaborative effort of 16 universities. It was created and supported with a grant for a 4-year period under the USDA Cooperative State Research, Education and Extension Service Fund for Rural America Program. The grant was to have terminated in January 2004 but has been extended to January 2005.

Headquartered at North Carolina State University, the center works to develop and disseminate knowledge and technology that support sustainable, profitable and internationally competitive animal production and also protect community interests and environmental quality. The Center has produced the following key outcomes.

White Papers were developed that summarize the current state of the science for 20 manure management issues, and an additional five papers are under development.

The Center coordinated responses to the EPA-proposed CAFO rules and Notice of Data Availability and conducted meetings with members of EPA and USDA to discuss these recommendations.

Based on the research needs identified in the White Papers, 19 research projects were supported with National Center funds. These projects were chosen to help provide data on key topics in animal production/manure management.

The Center's effective coordination of efforts to address animal manure management issues is serving as guidance for regional research projects.

The Center co-sponsored workshops in the United States, Japan and Korea, including the American Water Resources Association Specialty Conference and the US-EPA Sustainable Land Application Conference.

A team of more than 30 individuals from 15 land grant universities, USDA, NRCS, ARS and the EPA National Agriculture Compliance Assistance Center developed the Livestock and Poultry Environmental Stewardship Curriculum in cooperation with the National Center. This curriculum includes 26 lessons and supporting Power Point presentations. CAFO Fact Sheets are being developed that address questions educators and producers have about what the CAFO regulations mean, how they will affect livestock and poultry production facilities, and what producers must do to comply with the regulations. In addition, similar educational materials for small farms are being developed.

Southern Region Small Fruit Consortium

This consortium is a multistate, integrated activity that includes North Carolina State University, Clemson University, the University of Georgia and the University of Tennessee.

During 2003, the consortium Web site was revamped to make it easier to navigate.

Also in 2003, the Consortium joined with the Southeast Strawberry Expo to sponsor a special agent training on anthracnose of strawberries. Thirty-five county agents from the four consortium member states and Virginia attended the workshop.

And the consortium awarded grants totaling $59,648 in 2003 to fund the following research projects.

Validating Grape Disease Forecast Models for the Southeast

Production of a Comprehensive Pest Management Guide for Small Fruits

Alternative Frost/Freeze Protection Systems for Strawberry Production

Evaluation of Wintertime Sprays of Soybean Oil to Bloom and Thin Rabbiteye and Southern Highbush Blueberries

The Abatement of an Emerging Epidemic in Cultivated Blackberry: Phase 2

An Alternative Systems Approach to Blackberry Production

Effective Pollination Period of Rabbiteye Blueberry

Estimating Costs of Producing and Harvesting Blackberries in the Southeastern U.S.

Effects of the Plant Defense Activators Actigard and Messenger on Phenolic Compounds and Antioxidant Capacity of Blueberry Fruit

Evaluation of Reduced Sensitivity of Phytophthora Cactorum Isolates from the Southeast to Metalaxl

Biological Control of Spider Mites and Armyworms of Strawberries Grown Under Row Covers for Fall and Winter Production

Cross-Pathogenicity to Wine Grape of Xylella fastidiosa Cultures Isolated From Native Vegetation

Edible Chitosan Coatings as Novel Effective Biopesticides

Peanut Variety and Quality Evaluation Program

A cooperative agreement is in place between NCARS and the Virginia Agricultural Experiment Station (VAES) at Virginia Polytechnic Institute and State University for the field evaluation and joint release of Virginia-type peanuts. These peanut selections are bred by NCARS and VAES breeders, then evaluated in field trials managed by VAES researchers. Selections are evaluated, selected and recommended for release by an advisory board composed of NCARS and VAES faculty, peanut growers, shellers, and processors. NCARS annually provides half of the funds required to manage the field trials. This program is designed to evaluate the yield, maturity (genetic potential), quality characteristics and consumer acceptance of advanced Virginia-type peanut breeding lines. In the 2002 season, 22 peanut breeding lines from North Carolina were evaluated with 19 lines from Virginia and eight checks at four sites with two digging dates at each site.

The program also develops research procedures and management systems for the evaluation of peanut lines. Approximately 90% of the peanuts grown in North Carolina in 2003 were of eight cultivars (NC 7, NC 9, NC 10C, NC-V 11, NC 12C, Gregory, Perry, and VA-C 92R) that were developed and released either by North Carolina State University or in cooperation with Virginia Tech University.

Regional Apple Research and Extension Position
North Carolina State University joined during 2002 with Clemson University, the University of Georgia and the University of Tennessee to create a regional apple research and extension position, which has now proceeded through completion of faculty recruitment and selection in late 2003. This position is to focus on apple orchard management and is interacting with faculty, staff and extension agents from the four universities as well as apple growers from the four states. The position is located at NC State University's Mountain Horticultural Crops Research Station in Fletcher, North Carolina, and much of the research is being conducted there, although field research is being conducted in all four states. The research program is focusing on the use of plant growth regulators to aid in managing apple growth and production and evaluation of promising apple cultivars.

E. Multistate Extension Activities *(see NCCES AREERA report, not applicable to NCARS report)*

F. Integrated Research and Extension Activities

Research and extension activities are integrated within the College of Agriculture and Life Sciences at the administrative, departmental and faculty levels. The directors of the North Carolina Agricultural Research Service (NCARS) and the North Carolina Cooperative Extension Service (NCCES) work closely together and coordinate all aspects of administration, including position management, state budget requests, budget allocation, facility management and space utilization. Currently, there is an integrated effort to more closely align administrative structure of the directors' offices with programmatic areas across research and extension in the college.

Research and extension activities are integrated formally in a number of key program areas, in which faculty serve in the roles of research and extension coordinator or as a center director of multidisciplinary, multi-function programs. This approach has been particularly successful in water quality, animal waste management, integrated pest management, sustainable agriculture, air quality, small fruits and specialty crops program areas. These coordinator and center director positions are funded by both NCARS and NCCES, and operating funds are allocated from both offices.

In all college departments that have both research and extension faculty, these faculty are housed together and interact on a day-to-day basis in all operational and programmatic aspects of the department. This also promotes close interaction with faculty who teach, most of which have research or extension appointments.

The most complete integration of research and extension occurs at the individual faculty level. Over 70 of the 297 college tenured and tenure-track faculty with research appointments also have extension appointments. In fact, most of these split appointment faculty have 50 to 80% extension appointments, so their research programs are specifically designed to support their extension programs. These faculty serve as a strong link between those faculty who have a majority research appointment (usually split with teaching) and the county-based extension field faculty and state's agricultural industries. Working closely with the more basic, discovery oriented research faculty, these research/extension faculty, in conjunction with county field faculty, bring new knowledge and technology to the producers and agribusinesses through development, field testing and demonstration. In addition, certain faculty with research/teaching appointments have their research activities in program areas that are highly integrated with extension. These faculty work closely with one or more extension faculty to deliver the knowledge and technology gained from their research to clientele. These research faculty commonly give presentations at county agent training sessions, grower meetings and field days. Therefore, project expenditures for these faculty are included in NCARS total expenditure for integrated activity.

Since all research faculty have an approved federal or state research project cataloged on the CRIS database, the NCARS expenditures and personnel commitment for the research aspects of their activities can be documented. Altogether, there were 70 faculty with research and extension appointments who led integrated projects in 2003. Of those, 60 were supported by Hatch funds along with state, federal and other sources. Hatch expenditures for 60 of their projects amounted to **$1,953,591.91** which was **more than 31.3**% of the 2003 Hatch and regional allocation.

The following is the project/program names and brief descriptions of the NCARS Integrated Research-Extension programs, broken out by *National Goal Area.*

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

Integrated Project	***Project #***
Production strategies for improved vegetable production and alternative crops for diversification	**6596**
Weed management for small fruits and vegetables	**6327**
Genetic and production environmental influences on processing and planting quality of nutritionally enhanced soybean seed	**6632**
Management of arthropod pests of turf and peanut	**6502**
Ecology and management of European corn borer	**0205**
Plant nutrition programs for mountain crops	**6558**
Weed management and growth regulators for agronomic crops	**6417**
Cultural management of strawberries and grapes	**6324**

Using remote sensing to manage nitrogen in a corn-wheat-soybean rotation	**6425**
Development and refinement of strategies for peanut production in NC	**6466**
Developing new crops and sustainable production systems for vegetables and medicinal herbs	**6595**
Rootstock and interstem effects on Pome and Stone fruit trees	**1840**
Farming system impacts on strawberry and tomato diseases and soil microbial ecology: short and long-term	**6641**
Small fruit production systems	**5830**
Integrated peach disease management	**6160**
Management of arthropods in fruit and vegetables	**6402**
Crop improvement strategies	**6515**
Apple disease management	**6223**
Processes limiting pollen development and release under heat stress in tomatoes and other crop plants	**6623**
Small fruit diseases and their control	**6747**
Biological control of arthropod pests in weeds	**0303**
Development, evaluation and promotion of underutilized and novel ornamental plants	**6137**
Disease management in ornamental crops	**6364**
Assessing farming system sustainability and research support for organic agricultural production	**6625**
Price risk management strategies in food and grains marketing	**6510**
Mycotoxins and their effects on dairy cattle	**6348**
Genetic improvement in pork production systems and understanding genotype by environmental interaction	**6496**
Enhancing production and reproduction performance of heat-stressed dairy cattle	**0299**
Risk aversion, risk shifting and alternative payment mechanisms in settlement of broiler contracts	**6527**
Fish food ingredients produced by solubilization/reprecipitation	**6616**
Use of alternative supplements in grazed, hayed and ensiled forage systems for beef cattle	**6480**
Nutritional strategies to improve the growth, productivity, and profitability of dairy cattle	**6605**
Nutrient requirements of swine for profitable production	**6495**
Maximization of laying hen performance economic return, and egg quality	**6184**
Mountain aquaculture research	**6153**
Strategies to increase meat goat production	**6701**
Integrating crops and livestock systems	**6602**

Production strategies for improved vegetable production and alternative crops for diversification
Project 6596
To meet increased demand for seedless watermelons, commercial seed companies developed new pollinizers that take up minimal space and increase production on a per acre basis, but information as to whether pollinizers will work in a commercial watermelon production system on a consistent basis is lacking. Horticulture Science faculty from North Carolina State University and the University of Florida tested three pollinizer systems in 2003, and an additional test is planned for 2004. Results indicate that an increased yield of seedless watermelon between 10 to 25% can be realized by growers who use this method.

Weed management for small fruits and vegetables
Project 6327
Palmer amaranth is a weed that drastically lowers sweet potato quality and yield. Field trails found that mowing or hand hoeing at 10 to 20 days after sweet potato transplanting prevents quality and yield reductions by this weed. Herbicide trials showed that Dual, used as a preemergence herbicide, gives good control of Palmer amaranth. Based on these results, an emergency label for this use has been submitted to E.P.A. through the North Carolina Department of Agriculture and Consumer Services.

Genetic and production environmental influences on processing and planting quality of nutritionally enhanced soybean seed
Project 6632
Soybean and peanut phytotron studies were conducted in 2003. These studies evaluated the influence of temperature during seed development on subsequent seed quality of high oleic soybeans and peanut varieties. Field studies were also conducted in 2003 to evaluate soybean planting date, row width and harvest date. Analysis will be completed in 2004.

Management of arthropod pests of turf and peanut
Project 6502
A major research effort focused on the impact of using various management strategies to minimize the incidence of tomato spotted wilt virus in peanuts. An additional study focused on the incidence of southern corn rootworm injury as related to soil characteristics, variety selection and planting date and yield impact. A publication focusing on the tomato spotted wilt virus advisory was published and was widely used by growers. This research and extension effort has produced a rootworm advisory that provides sound decision-making principles for southern corn rootworm insecticide use. The tomato spotted wilt virus risk index has been validated and presented to growers. Its full implementation took place in 2003, and research indicates that by selecting the appropriate complement of cultural practices in 2003 growers may have reduced the incidence of tomato spotted wilt virus in peanuts by over 50%.

Ecology and management of European corn borer
Project 0205
Field tests using seed coatings to protect corn from wireworms and southern corn billbug were conducted in the 2001, 2002 and 2003 growing seasons. Results were positive, and two chemical

coatings, clothianidin and thiamethoxam, were commercialized for the 2004 growing season. Research data helped seed companies offer North Carolina corn growers the appropriate rates for wireworms (low) and billbugs (high). A vigorous outreach campaign educated growers, county agents and dealers of the advantages of this new technology. Insect control, human safety, and the environmental all benefit by replacing old insecticides with clothianidin or thiamethoxam seed coatings. Both compounds are much less toxic and safer for the grower to use. The new products are short-lived in the environment, have a very good environmental profile, and are used at rates from 92% to 99% lower than the products they are replacing. Since they are delivered on the seed, pesticide containers are not used, reducing exposure to the grower as well as solving container disposal problems. The new products also save time and effort. New seed treatments are priced competitively with older products but benefit the grower with improved yields. Tests showed insect control to be improved by as much as 40%, resulting in a potential profit of over $50 per acre under heavy insect pest conditions.

Plant nutrition programs for mountain crops
Project 6558
An under-the-row pre-plant method of applying phosphorus fertilizer to Christmas trees was developed and is being tested at two experiment stations and at nine on-farm locations in Western North Carolina. The method is still being tested, but increases in tree phosphorus content have been measured. If this method works as well as expected, it will drastically reduce phosphorus fertilizer applications to Christmas trees.

Weed management and growth regulators for agronomic crops
Project 6417
Italian ryegrass is the most serious weed problem in wheat across the Southeast. If uncontrolled, ryegrass can reduce wheat yields 30 to 90%. Growers have had to rely on a single herbicide to control ryegrass for the past 20 years, and as a result, resistance is now widespread. Research identified effective replacements and how best to use them. The research effort has produced the data needed to develop recommendations and educational programs on use of these new technologies as they become commercialized. The potential benefits for wheat producers could exceed $22 million.

Cultural management of strawberries and grapes
Project 6324
North Carolina strawberry growers faced an epidemic in the fall of 2003, when anthracnose was diagnosed in plug plants being grown in North Carolina from Canadian tips. North Carolina State University faculty members implemented an emergency program to aid growers. Faculty members traveled throughout the state to inspect numerous plug propagation facilities, while plant samples were processed at the NC State University Plant Disease and Insect Clinic. Growers received timely advice not only about the disease status of their plug plant material but also on whether it would be best to seek an alternative plant supply. Locating anthracnose-free alternative plant supplies proved difficult; there were few runner tips or plugs available from other plant suppliers. A nursery was able to furnish several million fresh dug plants to many former plug growers, who were uncomfortable with receiving fresh dug replacement plants from the same nursery supplier experiencing anthracnose problems in its runner tip production. The plant supplier could not completely make up for the deficit of plug plants across the region, so it became critical in late August to inspect fresh dug plants being grown in Canada as the next best alternative. Faculty members developed a nursery sampling procedure for collecting petioles from mother plants in fresh dug strawberry nursery fields. A faculty member flew to Canada and systematically sampled 800 mother plants in over 20 acres of fresh dug nursery fields. This plant material was brought through U.S. customs, then kept refrigerated until

delivered to an NC State University lab, where it was determined anthracnose was present in one of the two nursery fields. Nursery distributors were promptly
advised to ship to North Carolina growers only plant material from healthy fields. Faculty also worked to familiarize hundreds of farmers with the very different planting and transplanting procedures required for setting highly perishable fresh dug plants. It was not clear early in 2004 how successful this emergency response effort was; however, growers have expressed appreciation for on-line advisories as well as an on-farm demonstration and publications developed to address the situation. Faculty are also working with colleagues at the University of Guelph, the Ontario Strawberry Plant Propagation Program and the New Liskeard Agricultural Research Station of the University of Guelph in Northern Ontario to improve the supply of anthracnose-free planting stock coming to North Carolina to reduce future economic losses to this disease.

Using remote sensing to manage nitrogen in a corn-wheat-soybean rotation
Project 6425
Field studies in 1998 and 1999 in North Carolina proved the value of variable rate PIX application to cotton and the feasibility of using aerial infrared images to scout fields to determine PIX rates. In 2003,
further study was done to determine the accuracy of aerial scouting in determining PIX rates across a field and to determine the savings in terms of time and total amount of PIX applied. These tests found that: 1) site-specific PIX rates could be determined quickly and accurately with less field time and labor compared to other systems and 2) this system resulted in a 22% reduction in the amount of PIX applied. Based on the savings in labor and PIX observed in this study, aerial scouting reduces grower costs by $27 per acre scouted. Using the number of acres currently scouted for PIX application in the blacklands of North Carolina, this would result in an increase in grower income of $405,000

Cultural and pest management for optimum and stable peanut production
Project 6466
Results of tillage studies indicate that reduced tillage systems can be as successful as conventional tillage systems for peanuts in some but not all situations. It appears that peanuts produced in reduced tillage systems on coarse-textured soils respond equally as well as conventional tillage systems. In contrast, positive peanut response to reduced tillage systems on fine-textured soils may be less consistent. Results from the tillage by variety by digging date studies suggest that inconsistencies noted among tillage practices that have been reported previously most likely are not associated with variety selection or digging date. A risk advisory will be published early in 2004 to assist growers in transitioning to reduced tillage systems for peanuts.

Developing new crops and sustainable production systems for vegetables and medicinal herbs
Project 6595
Heirloom vegetables are increasingly popular among U.S. consumers, and the most popular of these are tomatoes. Most heirloom tomatoes are very soft and do not ship well. As a result, heirloom tomatoes are almost always grown for local sales. In 2002 and 2003, a large number of heirloom tomato varieties were grown at the Mountain Research Station in Waynesville, North Carolina. Field days were held to introduce growers to the varieties and demonstrate the production systems needed to grow them. To judge consumer acceptance and interest, taste tests, market surveys and test market trials were conducted at the Waynesville Tailgate Market, local roadside stands, a supermarket, the Western North Carolina Farmers' Market and the Grove Arcade in Asheville, N.C. A foodservice survey was also conducted. Heirloom tomatoes generated tremendous interest among growers and local consumers. Growers indicated they would grow more heirlooms tomatoes in 2004, while

consumers indicated that they would buy heirloom tomatoes if they were available. Local retailers and restaurants are interested in learning how to make arrangements with local growers to supply heirloom tomatoes throughout the growing season.

Post-harvest quality maintenance of horticultural crops; influence of orchard management on tree growth; rootstock and interstem effects on Pome and Stone fruit trees
Projects 6717, 6196 and 1840
Faculty at North Carolina State University developed a system that allows commercial apple operations in North Carolina to use SmartFresh, a postharvest product that extends the shelf life of horticultural crops. Apples treated with SmartFresh maintain their firmness, crunch and acidity much longer after harvest and even after being held at room temperature. Working with growers, NC State faculty showed it is possible to treat apples with SmartFresh in refrigerated trailers. Apples treated in this manner maintained their quality much longer than untreated apples. Based on this work, North Carolina growers have indicated an interest in treating their apples with Smartfresh. The economic benefit to North Carolina should be significant in that it will allow growers to maintain the high quality of North Carolina apples longer, which should extend the apple season as well as open new markets.

Farming system impacts on strawberry and tomato diseases and soil microbial ecology: short and long-term
Project 6641
Interdisciplinary, multi-state and (stakeholder) participatory research, extension and educational programs were implemented to evaluate, adopt and develop alternatives to the use of methyl bromide in strawberry and vegetable production systems. Twenty four Phase I trials (replicated trials on research stations) and 13 Phase II trials (demonstration or replicated trials on farms) were implemented from 2000 through 2003. Research focused on development of integrated approaches to manage key soilborne pests. The chemical alternatives Telone-C35, metam sodium, chloropicrin, and iodomethane produced yields equivalent to plots fumigated with methyl bromide on strawberries in North Carolina. Parallel work was done in vegetable production systems with an emphasis on tomatoes.

Small fruit production systems
Project 5830
Faculty at North Carolina State University identified several viruses that are likely associated with the decline of some blackberry plantings in North Carolina. The North Carolina State University Micropropagation Unit has virus tested and established in tissue culture virus-indexed nuclear stock of most of the commonly grown varieties. The certification standards will enable North Carolina to become the only state in the Southeastern U.S. to have certified blackberry nurseries. This could enable North Carolina to become the leading supplier of clean blackberry nursery stock in the region.

Integrated peach disease management
Project 6160
Consumers expect high-quality, blemish-free peaches with bright red skin color, among other characteristics. Many of the cultivars with these characteristics are highly susceptible to a bacterial disease, bacterial spot, that can render the fruit unacceptable. Some years the incidence of diseased fruit is more than 90% while in other years the same trees may have less than 10% diseased fruit. Growers often waited to observe the disease before applying the limited chemicals available. The use of chemical sprays in this manner failed to provide adequate disease control. After analyzing weather

data, North Carolina State University researchers determined that in years when the disease was severe there were frequent periods of rainfall during bloom and in the following three to four weeks. Sprays containing copper were applied prior to and during this period. This research has defined the critical fruit infection period as occurring early in the growing season near time of bloom rather than continually until fruit have ripened, thus potentially reducing the number of sprays while reducing fruit lost to this disease. The management strategy developed from this research is the basis for chemical control of bacterial spot on peaches in the Eastern United States.

Management of arthropods on fruits and vegetables in Western North Carolina
Project 6402
An effort to manage the development by twospotted spider mites on tomatoes of resistance to various miticides was begun. Twospotted spider mite populations were collected from different locations, and dose-response curves were determined for a range of new miticides entering the market place. This serves as base-line information for future monitoring of resistance development. Crop and non-crop habitats were monitored for mites from March through September in Rowan County, North Carolina to monitor movement of twospotted spider mite during the season.

Crop improvement strategies
Project 6515
Greenhouse growers rely mainly on visual monitoring of a crop to determine the nutrient status of the crop, a method that can be costly if pH or electrical conductivity (EC) values are not optimal. In an effort to find a better way to monitor crop nutrient status, faculty at North Carolina State University studied methods of conducting in-house testing using the PourThru Nutritional Monitoring program. The required techniques were refined, crop specific recommended ranges for pH and EC developed, charts for plotting trends developed and corrective measures listed. A 3-hour presentation was developed to explain the monitoring program to growers. Growers who have attended this presentation are now monitoring their crops and using the program to prevent losses. One grower who used the program discovered that pH was excessively low. The grower was able to correct the problem and salvage a $10,000 crop.

Apple disease management
Project 6223
A spray program for apples was developed that extends the interval between the last spray and harvest, thus decreasing the liklihood of pesticide residue on apples, while also providing good disease control. Gerber Corp., a major apple buyer, has asked that all growers in North and South Carolina who sell fruit to them use this fungicide spray program in 2004. The development of a reduced risk program for both fungicides and insecticides was a condition for Gerber to continue to purchase fruit from growers in North and South Carolina. In addition to growers who sell to Gerber, many other North Carolina growers are interesting in using the program because it is effective and less expensive than other programs.

Processes limiting pollen development and release under heat stress in tomatoes and other crop plants
Project 6223
High temperature injuries commonly reduce productivity in crops grown in tropical and temperate regions. If mean warming reaches the upper end of the predicted range (a temperature rise of 4-6 C), developing heat-tolerant varieties of major crops will become a vital task for plant breeders. This is particularly true for tomatoes. Previous research implicated pollen as limiting fruitset at high

temperatures, but it was not clear whether the amount of pollen produced, the amount released, the viability or all these factors were reduced by heat stress. It also was not clear whether any or all of these characteristics would be correlated with heat tolerance in the cultivars previously examined. In a series of experiments, pollen release and pollen germination were found to be well correlated with the ability of cultivars to set seeded fruit. Thus, pollen release represents a promising characteristic in cultivar selection for fruitset in hot, humid environments. This may be a useful characteristic in screening other heat-sensitive crops. Research also demonstrated interactions between heat and humidity stress and documented changes in carbohydrate and enzyme levels in the pollen and anthers of tomato and pepper plants that are affected by heat stress and that are related to pollen performance.

Biological control of arthropod pests in weeds
Project 6223
Research showed that a beneficial organism sold for cotton bollworm control is not efficacious in cotton because of the specific population dynamics of that system, leading to a recommendation that will save cotton growers the expense of an unnecessary product that had been used on between 50,000 to 100,000 cotton acres in the South.

Development, evaluation and promotion of underutilized and novel ornamental plants
Project 6137
In an effort to broaden the scope of new plants available to the North Carolina nursery industry and facilitate their distribution, a reworked and improved program called the JC Raulston Arboretum Premier Plants Program was developed. The director of the JC Raulston Arboretum at North Carolina State University and the leadership of the North Carolina Nurseryman's Association worked to develop the program name, logo and labels, guidelines, policy statement and program logistics. This program is helping to establish North Carolina as the premier state for ornamental nursery plant diversity for the commercial and residential landscape sectors.

Small fruit diseases and their control
Project 6747
Blueberry cultivars grown in northern states are neither climate adapted or disease resistant in the hot, humid South. As a result, "minor" diseases such as leaf spots and stem cankers become major impediments to production. In an on-going effort, USDA and North Carolina State University plant pathologists have worked hand-in-hand with plant breeders to develop disease-resistant blueberry cultivars adapted to low-chill climates. Disease investigations, control practices, and recommendations tailored for the extended growing season of the South have been under continuous development. In 2003, North Carolina blueberry growers harvested a record 22 million pounds of fruit with a market value in excess of $30 million. This would not have been possible without the long-term effort to establish disease-resistant cultivars and production methods for the South.

Disease management in ornamental crops
Project 6364
Two biocontrol agents, strain 5.5B of *Burkholderia cepacia*, and two strains of binucleate *Rhizoctonia* fungi sp., when used sequentially have shown potential to control Rhizoctonia stem rot and root rot in production of poinsettia. Strain 5.5B protects poinsettia from stem rot during propagation of cuttings, and the binucleate *Rhizoctonia* strains protect the rooted cutting during flower production. Other biocontrol agents, including strains of *Trichoderma virens,* were effective against Pythium damping-off in bedding plant production.

Assessing farming system sustainability and research support for organic agriculture production
Project 6625
The Center for Environmental Farming Systems developed an innovative direct marketing strategy that connects farmers to consumers at their place of work. Taking advantage of high concentrations of consumers, this transferable multi-farmer Community Supported Agriculture (CSA) model is being piloted at Research Triangle Institute and brings more profits directly to farmers as compared to traditional wholesale markets. Consumers appreciate the local, fresh products and become advocates for supporting North Carolina family farmers.

Price risk management strategies in food and grains marketing
Project 6510
Research done at North Carolina State University in collaboration with faculty at Kansas State University on the impact of food safety on meat demand suggests consumers respond differently to food safety concerns versus long-run health concerns. In particular, a meat demand model developed as part of this research effort indicates that, in general, there are no lagged effects on U.S. meat demand from publication of food safety information. This suggests that, although demand declines in the short-run in response to a food safety problem, consumers generally do not allow the food safety problem to impact their long-run consumption habits. It appears that only repeated food safety problems, which keep the issue in front of consumers for an extended period of time, lead to an ongoing adverse impact on demand. This research may be applicable to the discovery in December 2003 in Washington state of a dairy cow that tested positive for bovine spongiform encephalopathy, or mad cow disease.

Mycotoxins and their effects on dairy cattle
Project 6348
Nutrition and feeding recommendations available to North Carolina dairy farmers are supported by research at North Carolina State University. North Carolina Cooperative Extension specialists and agents provide the latest information to dairy producers and the feed industry. Ration formulation using alternative feeds and based on feed analysis has increased annual dairy farm profits by $100 per cow. Over 80% of North Carolina dairy producers are using these feeding recommendations. Dairy producers have adopted measures to prevent mycotoxin contamination of feed and have learned to prevent and to recognize and treat problems. These adopted feed practices are estimated to have increased annual dairy farm profits by $10 million. They have also improved the safety and quality of North Carolina produced dairy products.

Genetic improvement in pork production systems and understanding genotype by environmental interaction
Project 6496
A cooperative formed with assistance from North Carolina State University initiated value-added marketing programs. A production certification and training program was developed and provided to producers. Through the North Carolina On-farm Performance Testing Program, NC State University faculty members provided muscle quality evaluations on 400 head of swine provided by 11 producers. This information has been summarized and provided to the producers along with training programs on what this data means and how to improve pork quality and receive value. Changes in management and genetics programs have been implemented to enhance the overall quality of pork

products. In addition, this data has been used to secure the interest of distributors that deal exclusively with high quality pork products in both the domestic and export markets.

Enhancing production and reproduction performance of heat-stressed dairy cattle
Project 0299

A series of research publications, newsletter and popular press articles, and producer conferences provided information to producers about trends for declining dairy reproduction over the past 25 years. A previous and a current regional project have focused on genetic strategies to improve reproduction. As a result of these collaborative projects and through validation by the USDA Animal Improvement Programs Laboratory (USDA AIPL), a new genetic trait, daughter pregnancy rate (DPR) was included in the national dairy genetic database beginning in February 2003. With the availability of a new trait, the USDA AIPL with input from researchers at North Carolina State University and around the U.S., modified the Net Merit$ selection index to include DPR as one of the selection traits beginning in summer, 2003. Although heritabilities of fertility traits in dairy cattle are generally low, the amount of variation in daughter pregnancy rate among sires suggests that genetic selection progress can be made.

Risk aversion, risk shifting and alternative payment mechanisms in settlement of broiler contracts
Project 6527

Virtually all broiler companies use incentives to compensate their contract growers. Changes in production technology designed to meet consumer demand require that compensation mechanisms be updated or entirely redesigned. When a North Carolina company found that its existing payment scheme did not provide correct incentives to growers producing heavier birds, the company asked for help from North Carolina State University in redesigning their broiler production contract payment mechanism. After discussing the issue with division managers and carefully reviewing the production data, an NC State faculty member provided several alternative to the existing payment mechanism.

Functional Fish food ingredients produced by solubilization/reprecipitation
Project 6616

Considerable quantities of edible meat from trimmings and deboned carcasses of meat, poultry and fish are wasted, and many smaller pelagic fish species are hardly utilized for food, being converted primarily to fish meal for animal feed. North Carolina State University researchers, working in conjunction with colleagues at the University of Massachusetts and the University of Florida, developed two important processes to address this challenge. A new method of recovering and refining such meats, which removes fat, connective tissues (including skin) and bone, was developed and is being commercially scaled. And a method of solubilizing and injecting this meat protein into intact fillets and cuts of meats, poultry and seafoods was developed. In tandem these technologies enhance the texture and taste of meat, poultry and fish products while reducing the cost to consumers. The new meat recovery method also reduces treatable effluent from meat, poultry and seafood processing factories.

Use of alternative supplements in forage systems for beef cattle
Project 6480

The North Carolina Grazing Schools have impacted grazing practices throughout the state. Since the inception of the program, 525 students have been trained in 28 schools/seminars. Students rated the impact of the program on their ability to manage their farms highly (4.5 on a 1 to 5 scale) and

unanimously indicated they would recommend the program to other producers. Two producer grazing schools and a 9-day school for NRCS and extension professionals were conducted in 2003.

Nutritional strategies to improve the growth, productivity and profitability of dairy cattle
Project 6605
Dairy cows were fed a diet with lower crude protein in which the protein was less degradable in the rumen and was balanced for a 3:1 ratio of the amino acids lysince and methionine. In a study of cows fed this diet, milk production was maintained while nitrogen excretion to the environment was reduced by 18%.

Nutrient requirements of swine for profitable production
Project 6495
Reducing phosphorus excretion by using phytase in sow diets was investigated in cooperation with four other states in a multi-year project. It is anticipated that phytase can be used to replace a portion of the phosphorus in the diet and reduce phosphorus excretion by approximately 30% without affecting reproductive performance. Completion of this project is anticipated in September 2004. In addition, work is underway to reduce the environmental impact of swine production by removing fiber fractions from corn through processing (dehulled, degermed corn). Effects of dehulled, degermed corn and extruded corn on growth performance of nursery pigs, growing-finishing pigs and sows were minimal. However, nutrient excretion was reduced in pigs fed processed corn products. Effects on odor are being analyzed.

Maximization of laying hen performance, economic return and egg quality
Project 6184
A North Carolina State University faculty member directed and gave key presentations at the National Egg Quality School. The school is designed to give students the latest information about egg quality and the factors affecting quality. In 2003, 60 students from 20 states, one U.S. territory and Mexico joined more than 44,732 alumni from around the world who have attended this school or the Eastern/Midwest Schools over the past 73 years.

Mountain aquaculture research
Project 6153
North Carolina trout farmers have historically reported losses of up to 30% of their trout to disease. Research and demonstration work by North Carolina State University faculty members led trout farmers to a vaccine that has cut disease loss dramatically, particularly from enteric redmouth, often the most damaging disease with which growers must deal. *Yersinia ruckeri*, the causative agent of enteric redmouth disease, was reported as the primary cause of trout loss until recently, but adoption of better vaccination methods reduced mortalities from that disease and from diseases overall. Now, another method of protecting trout may be on the horizon. Working with colleagues from the National Center for Cold and Coolwater Aquaculture, NC State researchers have isolated and began genomic evaluation of a bacteriophage specific to *Yersinia ruckeri*. The virus, isolated from a trout farm in North Carolina, is lethal to the *Y. ruckeri* bacteria and may prove to be a valuable tool in the management of enteric redmouth on trout farms.

Strategies to increase meat goat production

Project 6701
North Carolina State University faculty members played an integral role in the organization of the North Carolina Meat Goat Producers Coop and continue to work with the organization. As a result, 400 farm families from 65 counties and four states are now certified members of the cooperative. Training sessions were held to certify 33 North Carolina Cooperative Extension agents interested in working with district affiliates of the cooperative. As a promotional effort, interested chefs from upscale restaurants were offered goat carcasses or cuts for free to add to their menus. Goat tasting days were held at the Raleigh and Greensboro farmers markets, the North Carolina State Fair and other events. Income was generated from direct sales of live meat animals and breeding stock and through an annual breeding stock sale. A coop website was developed and goat meat can be ordered on-line. The coop also works with three slaughtering/processing plants.

Integrating Crops and Livestock Systems
Project 6602
North Carolina State University's Center for Environmental Farming Systems is providing significant educational activities for students, agricultural professionals and farmers. The center also provides important information on organic production practices and long-term systems research. The recently instituted Third Thursday Program provides a monthly workshop on a wide range of activities for agricultural professionals and farmers. The center is also a regional model for sustainable agriculture research and education. In 2003 a range of groups and organizations visited the center. These included groups from Duke University's, Nicholas School of the Environment, Auburn University's Agricultural Experiment Station, the North Carolina Environmental Coalition and the Natural Resources Conservation Service National Pasture Ecology Workshop. Wes Jackson from the Land Institute in Salina, Kansas also visited the center.

GOAL 2
A SAFE AND SECURE FOOD AND FIBER SYSTEM

Transport phenomena in agricultural and biological processes	**5885, 6482**
The poultry food system: A farm-to-table model	**0292**

Improvement of thermal and alternative processes for foods
Projects 5885, 6482
Faculty at North Carolina State University have developed a radiant frying process that does not use oil. This process uses a spectrum of radiant energy of variable power and frequency in which fried characteristics can be imparted to the food without requiring immersion frying in oil.

The poultry food system: A farm-to-table model
Project 0292
A study was done to generate bacterial transfer data that could be incorporated into a microbial risk assessment model for evaluating the degree of risk to human health associated with poor handling practices of ready-to-eat food products. The degree of transfer of *Campylobacter jejuni* and *Salmonella enterica* serovar Typhimurium was evaluated from a stainless steel contact surface to a ready-to-eat food (lettuce). This study indicated that relatively high numbers of bacteria may be transferred to a food even 1 to 2 hours after surface contamination. Consequently, there is a need for

continuous disinfection practices to reduce contamination levels available for transfer as the risk of transfer of contamination is constantly present.

GOAL 3
A HEALTHY, WELL-NOURISHED POPULATION

Insect and manure management in poultry systems: Elements relative to food safety and nuisance issues	**1006**
Biology and control of nuisance vector arthropods in North Carolina	**6479**

Insect and manure management in poultry systems: Elements relative to food safety and nuisance issues
Project 1006
An extensive evaluation of the negative impact of mixing insecticides and disinfectants to control poultry pests and sanitize poultry houses was completed. Such practices increase the survival of Salmonella and reduce the efficacy of many commonly used disinfectants and insecticides. Results of this study clearly demonstrate the implications for the spread of pathogenic agents.

Biology and control of nuisance vector arthropods in North Carolina
Project 6479
The vertebrate animals fed upon by mosquitoes in Memphis County, Tennessee are being investigated in a collaborative project involving the University of Alabama and the Centers for Disease Control and Prevention, Division of Vector-borne Infectious Diseases. The goal of the project, which continues in 2004, is to determine which species of birds are utilized as hosts by mosquitoes in areas where West Nile virus transmission occurs. Results of the project should help to elucidate which bird species are reservoirs of West Nile virus.

GOAL 4
AN AGRICULTURAL SYSTEM WHICH PROTECTS NATURAL RESOURCES AND THE ENVIRONMENT

Environmental nursery crop production	**6224**
Precision agriculture for agronomic crops and nitrogen management for corn in Eastern North Carolina	**6652**
Evaluation of tillage practices, organic production, and trickle fertigation for nutrient management	**6648**
Evaluation and modeling of riparian buffer performance in the Neuse River Basin	**6609**
Development of plant pathogens as bioherbicides for weed control and weed management in landscapes	**1001**
Improving sediment and erosion control measures	**6559**
Nutrient and by-product utilization and health of turkeys and broilers	**6343**
Effect of management on turkey production, turkey	**6390**

reproduction and turkey waste handling	
Agriculture and ground water quality	**6577**
Animal manure and waste utilization, treatment and nuisance avoidance	**1000**
Improved efficiency of water reuse aquaculture systems	**3975**
Aquaculture of Southern Flounder and improved water quality management of ponds in Eastern NC	**6387**
Development of tools for assessing environmental impact and remediation of agricultural and development activities on a watershed scale	**6568**
Integrated vegetation management in non-cropland environments	**6305**
Community-wide impacts and management of septic systems	**6372**

Environmentally compatible nursery crop production practices
Project 6224
The value of adding clay to soilless nursery container substrates has been debated since 1964. Even though amending pine bark substrates with clay would appear to have many potential benefits, there is little empirical evidence to definitively answer this question. Research at North Carolina State University evaluated different clay particle sizes and temperature pretreatments. Plant growth was comparable for all treatments, measured by shoot and root dry weight. All treatments with clay additives used less water than the pine bark and sand control substrate. Water savings varied from 9 to 18%, resulting in 3 to 6 gallons less water used per 5 gallon container to produce the same growth as control substrate. Water savings were greater with the smaller particle size. The smallest particle size saved 13.5 ounces per pot per day. Researchers calculated that savings per season per growing acre could amount to 100,000 gallons of water. Heat treatment of the industrial clays seemed to make no difference on water application rate.

Precision agriculture for agronomic crops and nitrogen management for corn in Eastern North Carolina
Project 6652
Nitrogen fertilizer management guidelines such as optimizing nitrogen rate and placement have been refined and, in some cases, used with precision farming tools. This information is included in ongoing education programs for farmers and county agents. This program enhances voluntary adoption of best management practices and generates acceptance of mandatory practices needed to achieve nutrient reduction goals for runoff into rivers.

Evaluation of tillage practices, organic production, and trickle fertigation for nutrient management
Project 6648
North Carolina State University scientists have developed conservation tillage systems that reduce or eliminate water and soil runoff from farm fields. A majority of farmers across Western North Carolina, where the terrain tends to be steep and erosive, have adopted these conservation tillage practices for corn production. Farmers have started to use these methods for tobacco and vegetables. Farmers using conservation tillage and winter cover crops leave plant residue on the soil surface.

This surface coverage reduces water and soil runoff to streams and improves water infiltration into the soil, reducing irrigation costs.

Evaluation and modeling of riparian buffer performance in the Neuse River Basin
Project 6609
A study is being conducted to compare the effect of riparian buffer vegetation type and width on shallow groundwater quality in the Coastal Plain region of North Carolina. Collection of surface and shallow groundwater samples continued at prescribed intervals in 2003. Redox instrumentation and measurements also continued. This study indicates that riparian buffer effectiveness is closely linked to the site hydrology, and that implementation of riparian buffers without knowledge of site hydrology may lead to minimal water quality benefits.

Development of plant pathogens as bioherbicides for weed control and weed management in landscapes
Project 1001
North Carolina State University researchers initiated a series of experiments to determine optimum control guidelines that provide both control of Japanese stiltgrass, an invasive weed, and encourage establishment of native vegetation. Several effective means of controlling Japanese stiltgrass were identified, as were selective herbicides. Comparing these treatments with traditional non-selective treatments, this research has demonstrated that selective removal is effective and promotes the establishment of native vegetation. A regional workshop was organized to raise awareness of the importance of this weed and the effectiveness of these selective treatments. As a result, two herbicide manufacturers have committed to updating product labels to allow use of their products in infested sites.

Improving sediment and erosion control measures
Project 6559
Using the Sediment and Erosion Control Research and Education Facility on the North Carolina State University campus, researchers are conducting field-scale, replicated studies of current and improved sediment control systems. Information collected at the facility has led to knowledge of the conditions necessary for polyacrylamide (PAM) logs to reduce runoff water turbidity. Alternative methods of introducing PAM into storm flows and water pumped from construction excavations have been evaluated.

Nutrient and by-product utilization and health of turkeys and broilers
Project 6343
A new technology called *in ovo* feeding (administration of nutrients into the amnion of embryos) was developed to improve early enteric development of poultry and improve resistance to enteric disease. *In ovo* feeding of solutions containing protein and amino acids increased early growth rate by 3 to 10% over controls. Enteric development was accelerated 48 hours after *in ovo* feeding, such that the *in ovo*-fed birds had a similar gut at hatch as 2-day-old control birds. This technology was patented and is being transferred to the poultry industry for further research and development. Information from this program was disseminated to the poultry industry by extension demonstrations, county and state-wide meetings, workshops, conferences and popular press.

Effect of management on turkey production, turkey reproduction and turkey waste handling
Project 6390

A novel poultry litter material called agro-chips made from old newsprint, cotton waste and gypsum was evaluated to determine its suitability as an alternative to the pine shavings now widely used. An experiment was conducted to examine the effect of litter type on commercial turkey tom and hen performance. Birds reared on pine shavings were compared to birds reared on agro-chips. All the pens in this study had considerable caked litter by the end of the rearing period. Further testing under field conditions is desirable to compare agro-chips litter to pine shavings under commercial conditions; however, this study indicated that agro-chips litter is a potential alternative litter material to pine shavings, especially during the brooding period when relatively little litter caking occurs.

Agriculture and groundwater quality
Project 6577
North Carolina State University faculty members are evaluating a range of swine waste management technologies that are seen as potential alternatives to the lagoon and spray field system now used on the majority of North Carolina swine farms. These evaluations will provide objective information that state legislators and regulators may use to make informed decisions regarding swine waste management in North Carolina.

Animal manure and waste utilization, treatment and nuisance avoidance
Project 1000
A substantial portion (estimated at 40-60%) of manure produced by swine is directly related to the fiber content of the diet fed. Removing this fiber prior to feeding may reduce nitrogen and organic waste production. Corn was processed to remove hulls and germ, both high-fiber components, leaving the endosperm as a feed ingredient for pigs. Feeding pigs degermed, dehulled corn reduced waste production by approximately 40% while possibly reducing odor emission without negative effects on animal performance. Degermed, dehulled corn has the potential to reduce manure production substantially without negative effects on animal performance.

Improved efficiency of water reuse aquaculture systems
Project 3975
North Carolina State University faculty members conducted a demonstration and evaluation of the BenRad water purification system in intensive aquaculture applications during 2003. BenRad AB is a Swedish firm specializing in the development of new technology for sterilizing water. The water purification system was evaluated for use in intensive fish farming. An initial test was completed in late 2003. While the unit (when clean) provided a 99.7% kill of total coliform bacteria, the results were variable when the unit became coated with minerals from the water. This study continues in 2004.

Aquaculture of southern flounder and improved water quality management of ponds in eastern NC
Project 6387
Commercial culture of flounder, widely and profitably practiced in Europe and Japan, has not yet been attempted in the United States. Southern flounder has great promise for aquaculture, with a high market value and unique ability to grow well in fresh water. North Carolina State University faculty members have succeeded in producing commercial-scale quantities of weaned fingerlings. This research has defined the dietary protein requirements for juvenile Southern and summer flounder as well as the fatty acid requirements of larvae. These accomplishments are fundamental steps in the development of nutritionally complete diets that will maximize the economic viability of flounder

farming. Growth studies of fish cultured at different salinities show that Southern flounder can be raised in fresh water beginning at a very early age without affecting their survival or growth rate.

Development of tools for assessing environmental impact and remediation of agricultural and development activities on a watershed scale
Project 6568
North Carolina State University has partnered with five other land grant universities to initiate a novel project for measuring and understanding airborne emissions from animal production facilities. The APECAB (Air Pollutant Emissions from Confined Animal Buildings) project is focusing on air quality associated with swine and poultry production. Six automated, real-time data collection systems, which utilize state-of-the-art analytical equipment and EPA standard procedures, are monitoring buildings in which animals are housed in six states. Odor samples are taken periodically to correlate with other data collected. Feed and manure samples are also being taken in an effort to construct a complete nitrogen balance for each facility. This project is collecting the first definitive, relatively long-term data detailing indoor and outdoor air quality associated with production facilities that are representative of a large percentage of the confined animal production facilities in the United States.

Integrated vegetation management in non-cropland environments
Project 6305
Weeds in aquatic and non-cropland environments interfere with intended uses of the areas, pose a potential threat to human health or safety and cost millions annually for management. Seed germination tests and greenhouse studies on tree of Heaven, a serious pest tree along highway rights-of-way, found that immature seeds could germinate and that even small root fragments left in place could resprout. This research showed that mowing would lead to more serious infestations along roadsides and, ultimately, could cost the taxpayers more money for roadside vegetation maintenance. Studies on the control of variable-leaf watermilfoil, a serious pest in ponds, showed that the timing of aquatic herbicide fluridone applications was critical to successful control. Early spring treatment gave excellent results, whereas mid-summer treatment gave only partial milfoil suppression, with complete regrowth by the end of the season. This research will provide taxpayers and private pond and lake owners a more effective tool for management of this weed, while saving thousands of dollars that might be otherwise wasted by applying the treatments too late in the season. This project was concluded during 2003 with the departure of the PI.

Community-wide impacts and management of Septic Systems
Project 6372
On-site wastewater systems account for 50% of the wastewater treatment systems in North Carolina. The current best management practices for siting systems may lead to premature failure of systems. Research at North Carolina State University has shown that the current method of assessing soil wetness overestimates the depth to seasonal wetness. Seasonal wetness is a major cause of system failure, thus overestimating its depth results in systems being installed too deep in the soil, which can lead to premature failure. Locating and installing systems shallower in the soil based on revised soil criteria may save the cost of repairing or replacing a failing system. Approximately $70 million is spent annually to repair failed systems. Proper siting of systems based on more conservative soil criteria could save North Carolinians upwards of $35 million as well as alleviate an environmental and public health risk.

GOAL 5
ENHANCED ECONOMIC OPPORTUNITY AND QUALITY OF LIFE FOR AMERICANS

Implications of technological and social changes for the food system	**6465**
Economics of socially optimal pork production	**6706**
The public economics of fast growing regions	**6532**
Sports fisheries enhancement in multiuse reservoirs	**6270**
Rural communities, rural labor markets and public policy in North Carolina and the Southeast	**1011**

Implications of technological and social changes for the food system
Project 6465
Researchers have analyzed consumer acceptance and behavior related to biotechnology over time and across many countries. At the same time, a range of stakeholder groups from leading academic, business and government organizations have been polled on biotechnology issues. These efforts have provided insight that has aided in the development and regulation of agricultural biotechnology and improved private and public sector decision making related to biotechnology.

Economics of socially optimal pork production
Project 6706
Alternative swine feeding programs and of a variety of alternative manure management systems being evaluated through the North Carolina State University Animal and Poultry Waste Management Center. Systematic evaluation of the expected costs and returns to each of these technologies is viewed as being of critical importance in determining the direction of legislation, regulation and design of pig production systems in North Carolina.

The public economics of fast growing regions
Project 6532
An economic model was developed that is being used to estimate the statewide net impact on jobs, income and state public revenues and costs of using business incentives funds to attract new firms to the state. In 2003, the model was used to analyze 15 proposals to spend business incentives funds.

Sports fisheries enhancement in multiuse reservoirs
Project 6270
A combination of field sampling, radio telemetry and mark-recapture population estimation modeling was used to examine the diet, growth, habitat use, movements mortality rate and abundance of flathead catfish, an introduced species, in three North Carolina coastal plain rivers. These findings were then incorporated into an ecosystem foodweb model to estimate impacts on the native fish community and evaluate various management strategies.

Rural communities, rural labor markets and public policy in North Carolina and the Southeast Project 1011

An analysis of employment, migration and commuting data for the 13 Southern states showed that about 60% of new jobs in a given county are filled by non-residents of the county – either commuters from nearby counties or by new residents moving to the county. These findings are important for local officials in rural counties in several ways. First, given recent declines in historically important rural industries (such as agriculture and textiles), industrial recruitment is almost universally viewed as a key element in replacing the lost sources of income for current county residents. That less than half of new jobs actually go to those residents means that this goal is not being fully met. On the brighter side, the fact that workers are so mobile means that the residents of a given county will benefit from the success of nearby counties in attracting new jobs and industries.

Summary:

Research-Extension Integrated Project Initiatives with Hatch Funding Sources: 60

Total Hatch funding allocated to the 60 projects for FY 2003: $1,953,591.91

Total Hatch allocation for 2003 was $6,149,277. With any carry over for prior years as well as any unspent Hatch funds in 2003 taken into account, the actual expenditure for 2003 was $6,238,481.94.

Percent of total Hatch funds allocated to Integrated projects amounted to 31.3%

HATCH EXPENDITURES FOR 2003

FOR INTEGRATED RESEARCH-EXTENSION ACTIVITIES
by National Goal Area

	FY 2003
GOAL 1: **An Agricultural System that is Highly Competitive in the Global Economy**	**$1,025,393.97**
GOAL 2: **A Safe and Secure Food and Fiber System**	**$24,966.85**
GOAL 3: **A Healthy and Well-Nourished Population**	**$88,424.68**
GOAL 4: **An Agricultural System Which Protects Natural Resources and the Environment**	**$715,315.27**
GOAL 5: **Enhanced Economic Opportunity and Quality of Life for Americans**	**$99,491.13**
Total	**$1, 953,591.91**

Certification Signed by:

Steven Leath 4-1-2004

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Steven Leath, Date
Interim Director