North Carolina Agricultural Research Service

Annual Report of Accomplishments and Results

2005

AREERA REPORT

Agricultural Research, Education, and Extension Reform Act

North Carolina Agricultural Research Service
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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 2005 NCARS personnel include 369 tenured and tenure-track research faculty accounting for approximately 193.6 full-time scientist equivalents, most on shared appointments with academics or extension. Working with these faculty members are over 465.5 research professors, researchers, research assistants, professional support staff and graduate students; 431.1 laboratory or field technicians, and other technical support; and 148.1 clerical/other staff. These faculty members and support personnel conduct basic and applied research in 501 projects to support more than 70 commodities as well as many related agribusinesses and life science industries.

The following AREERA Annual Report of Accomplishments and Results corresponding to the 2005-2006 Plan of Work Update, 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.

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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 wine grapes. 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, protecting from and managing pests and pathogens, harvesting, storing, and marketing these commodities. The introduction of new pests and the development of pests resistant to commonly used pesticides are also providing NCARS scientists challenges to provide management strategies for them.

The performance goals under the AREERA Goal (1a) plan of work 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 post harvest handling techniques for field, fruit, specialty and vegetable crops.

1) Thirty field factors are being evaluated in a RAMP project for their effect on postharvest susceptibility of sweetpotato roots to decay caused by *Erwinia chrysanthemi* and *Rhizopus stolonifer*. Preliminary results suggest that planting date and harvest date influence susceptibility to these postharvest decay organisms.
2) Dry sorting of blueberries was found to reduce postharvest decay by 60% compared to berries handled wet when picking buckets and inspection tables were contaminated with fungal spores.
3) Postharvest decay of blueberries was reduced 5 to 16% by the use of preharvest fungicide applications.
4) Blueberry cultivars were shown to vary in the amount of postharvest decay depending on whether or not the stem scar was wet or dry. The blueberry cultivar 'Blueray' (wet stem scar) had 17-19% more decay in postharvest handling experiments, compared to 'Bluechip' (dry scar).

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

1) Field studies with corn indicated that a starter fertilizer with additional potassium increased

rooting depth by 1-2 inches, root volume, and grain yield by 22 bu/acre.

2) Studies in cotton found that aerial color infrared photographs used in conjunction with field scouting could accurately determine mepiquat chloride rates for controlling cotton growth, which will lead to a reduction in scouting and chemical costs.
3) Seeding studies of soybean indicated that the economics of the high seeding rates generally used by producers is unfavorable, and that populations as low as 50,000 seeds/acre full season, or as low as 100,000 seeds/acre double crop, could be used without sacrificing yield.
4) Glyphosate-resistant Palmer amaranth was found in North Carolina during 2005 and a survey for resistant biotypes was conducted throughout the cotton production regions of the state to determine the extent of the biotype.
5) The critical periods of interference of volunteer Clearfield (imidazolinone-tolerant) corn, grass and broadleaf weeds in peanuts was determined as well as the temporal aspects of their interference on crop and weed biology.
6) Response curves for growth and reproduction of *Commelina benghalensis* (spiderwort) indicated that the optimum temperature is about 31 to 32C. This indicates that the geographical range of the species extends north of the Carolinas, consequently it could become serious noxious weed pest in North Carolina.
7) Economically feasible fumigation alternatives to methyl bromide used in the production of strawberries in the southeastern U.S. have been identified. Although technical issues currently associated with some of the alternatives persist in the Piedmont and Coastal Plain of North Carolina and Georgia, soil treated with chloropicrin showed the best results with an additional return of $1670/acre relative to methyl bromide followed by Telone-C35 with additional return of $277/acre.
8) Studies on the effect commercial organic and conventional substrates, a sample grower mix (peat, perlite, vermicompost, feather meal, kelp meal) and their components on seed germination and seedling growth of tomato (*Lycopersicon esculentum* Mill cv. 'Celebrity') provided data that have led to recommendations for organic tomato transplant growers that optimize seed germination, as well as transplant growth and nutrition utilizing either commercial or on-farm blends.
9) A management program for tomato spotted wilt virus has been developed that will enable growers to protect their crops from significant losses while cutting production costs. A fully integrated insect management program typically reduces insecticide use by one to two applications ($16-$32/acre) in comparison to the state average (which has already been lowered from historical highs by previous efforts). Use of tomato spotted wilt management tools if fully adopted can reduce losses to this disease by 50-75% ($25 to $37million per year).
10) Increased knowledge of the relationship between environmental conditions and peach growth stage has lead to more optimal timing of applications of bactericides to control bacterial spot.
11) A survey of floral crops found that Phytophthora diseases and resistant strains of *Phytophthora* are widespread and suggests that growers do not have adequate integrated pest management (IPM) programs in place to manage for them.

Performance goal 3 focuses on improving the acceptability and quality of field, fruit and vegetable crops.

1) Experiments with soybean with variable levels of phytate in seeds found that seed viability was not associated with the low phytate trait; and thus, low phytate soybean varieties should have good seed quality. Also, there was no significant difference in protein functionality between protein isolates prepared from low-phytate soybean and normal soybean.

2) Two public peanut cultivars were released, including Brantley (a high-oleic large-seeded virginia-type cultivar) and Phillips (a high-yielding cultivar).
3) Four peanut lines were released exclusively to private firms including three boiling peanuts (N97085J, N99080, and N99085J) and one high-oleic runner-type line (N991060l). An additional peanut germplasm line was publicly released (N96076L) with high levels of multiple pest resistance.
4) Two winter hardy oat germplasm lines were identified that have significantly more winter hardiness than other oat lines evaluated.
5) Four honeydew varieties have been identified with excellent culinary characteristics that are resistant to cracking and are very productive under North Carolina conditions. Two were test marketed in 2005 and received a favorable response. The favorable response from the marketplace in 2005 should result in increased acreage of honeydew melons in North Carolina in the future.
6) Three improved clones of the sweetpotato Beauregard were released. These clones have been widely accepted by growers allowing them to improve productivity and quality. During 2005 'Covington' a new tablestock variety, was approved for release and is Plant Patent Pending. Over 5,000 acres of 'Covington' were planted in 2005, representing ca. 15% of the total acreage of sweetpotato planted in NC. Based on NCDA&CS and USDA NASS crop value estimates of $80 million for the 2005 crop, the farm-gate value for 'Covington' in 2005 was ca. $12 million. We expect 'Covington' will account for ca. half of NC's sweetpotato crop in 2006.
7) Several new fresh market apple varieties have been identified that are suited to environmental conditions in North Carolina, including Ambrosia, Cameo, September Wonder, Suncrisp, Autumn Gold and Honeycrisp. These varieties will ensure continuing viability and success of the apple industry in the region.

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

1) A management plan was developed to control annual blue grass in golf courses. This grass is the most troublesome pest in highly maintained turfgrasses in North Carolina.
2) Research results indicated that sequential applications of Certainty (sulfosulfuron) + MSMA spaced 6 wk apart provide 50-75% control of dallisgrass in turfgrass for an entire growing season, which is an improvement over other currently labeled herbicides.
3) The interaction of salinity and nitrogen nutrition in turfgrass systems was documented and showed that nitrogen deficiency masks the harmful effects of salinity stress, and that moderately saline water can be used on bermudagrass turf without increasing nitrate leaching.

4) A drought tolerance gene and four fungal disease resistance genes were introduced into tall fescue which improved drought tolerance or resistance to brown patch and gray leaf spot diseases in transgenic plants.
5) Differences in ascorbic acid metabolism were found in wildflower species that correspond to observed differences in ozone sensitivity.
6) Relative attractiveness of petunia, fava bean, impatiens, begonia, gloxinia, chrysanthemum, and tomato to western flower thrips were investigated. Petunia was shown to be a superior indicator plant to fava bean; in addition petunia was more attractive to thrips than all crop plants except begonia.
7) The fungus that causes a previously undescribed disease of creeping bentgrass, Pythium root dysfunction, was identified. Observations indicate that the pathogen damages the root system

in the fall and spring when creeping bentgrass roots are actively growing. The fungicides pyraclostrobin and cyazofamid provide excellent curative suppression for up to 30 days. These preventative and curative programs cost $800 to $1000 per acre per month, which represents a significant reduction in the cost of control.

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.

1) The extensive collection of *Cercis* (redbud) species at the JC Raulston Arboretum has facilitated breeding efforts aimed at developing new cultivars of this important landscape plant group. New forms demonstrating various combinations of novel architectural forms, leaf and flower color, leaf variegation, and plant size are currently under trial for determination of potential landscape value.
2) Sterile ornamental forms of *Buddleia* have been developed that will allow continued deployment of this widely used ornamental shrub in the landscape without the risk of invasive spread into natural ecosystems and native plant communities. By reducing or eliminating via genetic manipulation the concern of invasiveness potential, the nursery industry can continue to produce and market this economically important and widely grown ornamental plant. Furthermore, availability of sterile *Buddleia* will allow the nursery industry to develop new promotion and marketing strategies for these sterile forms, and increase the acceptance and use of this plant in the home landscape

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. Additional studies not under the APWMC umbrella have also been conducted.

1) The state's swine industry and associated allied agribusinesses is estimated to employ approximately 50,000 individuals state wide and contribute approximately $8 billion annually to the state's economy. Environmental and social issues associated with this industry are impacting its potential for growth and long term sustainability. Research for new technology

has resulted in the identification, and economic costs associated with, several technologies capable of meeting state and federal environmental standards that can address the referenced environmental issues. Policy makers now have available objective scientific and economic information necessary for implementation of institutional programs and time line strategies for conversion to new and innovative animal waste treatment methodology. Several of the new technology strategies result in energy by products.

2) Low-cost, biological sludge management in anaerobic swine waste management lagoons in North Carolina; small business recruitment to Southeastern North Carolina; contribution to environmental and economical sustainability of swine industry in North Carolina.
3) The sustainability of the swine industry in North Carolina depends to a large extent on future environmental regulations. A NCSU program serves, in part, to provide unbiased information and research that will allow for environmentally sound swine production. A reduction of 20 to 50% in excretion of nitrogen, phosphorus, and micro-minerals could be achieved at a cost that is likely to be less than the cost of handling manure after excretion.
4) Applied research and extension activities have promoted the adoption of water quality best management practices by North Carolina beef producers. Research has demonstrated that compacted loafing areas in the riparian area lead to excessive rainfall runoff, and loading of nutrients and sediment into surface waters. A new award program, "North Carolina Environmental Stewardship Award" has been developed to recognize beef producers that promote and practice environmental stewardship.
5) Intermittent aeration (IA) process has been investigated for nitrogen removal from anaerobically pre-treated swine wastewater (APTSW) that contains a high concentration of ammonia and a low organics/nitrogen ratio. Nitrogen removal from the APTSW was achieved through nitrification and denitrification in a single, semi-continuously fed reactor that was operated with alternation of aeration and non-aeration. This technology would provide an efficient method to control ammonia emission and remove nitrogen from wastewaters. The results from the projects indicate that high ammonia and nitrogen removal can be achieved with the novel technology. Removal of ammonia from the wastewater would significantly reduce ammonia air pollution.
6) A multidisciplinary team was assembled to develop a methodology for conducting a business feasibility analysis for marketing value-added products derived from alternative swine manure treatment systems and to identify potential value-added products and information for characteristics of these value-added products to determine the ones with the highest profitability potential. The project used an example product to demonstrate the implementation of target costing and value engineering processes.

Numerous studies focused on improving animal health were conducted.

1) Misdiagnosis of estrus is the most common management mistake on swine farms in the U.S. occurring on a regular basis on over 60% of the farms in the U.S. Depending on their severity, these mistakes normally reduce farrowing rates by 10 to 15% and litter size by one to three pigs. Economically, it has been estimated that this costs the U.S. swine industry between $30 to $90 million annually.
2) By allowing dairy producers to achieve acceptable pregnancy rates during times of heat stress this treatment has the potential to decrease days open (when cows are not pregnant) by as much as three months. Each day open costs producers $1-2 per cow. The cost of the CIDR would be paid for by a decrease of two to three in days open.

3) Researchers at North Carolina State University and Northwestern University have utilized egg-laying chickens as a model for studying prevention strategies of ovarian cancer. This model will enhance the ability of medical researchers to verify and determine the efficacy of cancer chemopreventive drug regimens. This model may support the development of acceptable preventive programs and provide for an early detection mechanism for ovarian cancer.
4) Transgenic pigs can become a standard method for research on human health problems. The advantages to this strategy are evident and proven by the research with the rhodopsin transgenic pigs. Size, anatomy and physiology place the pig in a class by itself—much like human beings. Genetic manipulation such as transgenesis will augment more traditional techniques and allow for significant advances in human medicine.
5) The majority of North Carolina feeds submitted for mycotoxin analyses are positive. Mycotoxins can reduce milk production by 2 to 8 or more pounds daily, and are detrimental to health and reproduction of the cow. Aflatoxin residues in milk are illegal and contaminated milk must be discarded. Dairy producers have adopted measures to prevent mycotoxins and have learned to prevent and to recognize and treat problems.

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.

1) Cheese-making shortcourses were conducted in for prospective cheese makers. Those shortcourses conducted by the Food Science Department were designed to convey the basic concepts of Farmstead cheese production including basic sanitation and milk processing, basic and cheese microbiology, hands-on cheesemaking and packaging and labeling issues. Several farms have started specialty cheese-making from pasture-based dairy cows.
2) Almost all beef cattle mineral supplements have been switched from copper oxide to forms of copper that cattle can better absorb. Assuming that 25% of the beef cows in North Carolina graze forages that are copper deficient, and a 75% calf crop, this change has resulted in approximately a one million dollar increase in income from calf sales alone. For the entire U. S., this would mean a 90 million dollar increase in income from calf sales. This does not include any improvement in animal health that may have resulted.

3) Eggs subjected to improved incubation conditions produced chicks that exhibited more complete development upon hatching and responded to hotter brooding conditions with improved feed consumption, livability, and growth. Companies that have utilized these strategies have reported a measurable improvement in performance.
4) The use of enzymes and feed additives reduced feed costs by at least $2.00 per ton, resulting in a savings of over $60 million to the North Carolina poultry industry. Using natural feed additives and enzymes and more biosecure management practices, at least 4 major integrated poultry companies operating in North Carolina have stopped using antibiotic growth promoters to manage gut health and nutrient utilization.
5) Duckweed has the potential to convert environmental nitrogen to a protein source for cattle or other animals. Recent research shows that steers will readily consume duckweed and that duckweed can be used as a protein supplement for cattle. Current methods for harvest and preparation of duckweed for feeding are labor intensive and would limit application to relatively small systems.

6) For nearly 50 years, turkey embryo survival has been determined by developmental conditions controlled by a thermostat or humidistat. However, recent research suggest that a better means of controlling the development of avian embryos may be through the use of sires selected for increased body weight with dams selected for increased egg production. Technologies exist to control environmental incubator conditions to further refine and optimized embryo survival.

Biosecurity of animal production farms is extremely important for animal health as well as food safety. Efforts to improve bio-security can be in the form of improved farm management.

1) House fly role in viral disease transmission is directly linked to infectious dosages acquired within 3 hours. Risks have been identified for the poultry industry relative to the practice of mixing insecticides and disinfectants to control poultry pests and sanitize poultry houses. Such practices reduced the efficacy of many commonly used chemicals. Results of this study clearly demonstrate the implications for the spread of pathogenic agents.

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
$4,483.645	$26,108.541	$3,712.470	$6,400.877	111.60	242.65	272.46	38.56

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 use fertilizers, insecticides, and herbicides more efficiently. Soil inhabiting insects that feed as larvae on sweetpotato roots are major limiting factors in sweetpotato production. Feeding by these insects damages the sweetpotatoes and reduces marketable yield as well as quality of harvested roots. Sweetpotato producers currently attempt to control losses to these insects through the use of insecticides, including a pre-plant, soil incorporated application of insecticide, followed by as many as 5 or more applications of insecticide sprays to the foliage during the season to control adults of the root-feeding insects before they lay eggs. Research demonstrated that the foliar insecticide sprays provide no additional protection against root feeding insects.

b. Impact: This finding will enable growers to eliminate foliar sprays, which consist primarily of organophosphate, and chlorinated hydrocarbon insecticides currently targeted by EPA under the Food Quality and Protection Act. Elimination of these sprays will not only reduce the amount of pesticides used in sweetpotato production but also reduce production costs for NC Sweetpotato producers.

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

Key Theme: Diversified/Alternative Agriculture

a. Issue: Winegrapes are an attractive alternative to tobacco because of their high value. Since 2001, the winegrape industry in NC has grown by about 15% and growth is expected to continue at 10% per year. There are now 54 wineries in NC. Based on a model from California, it has been projected that the 10-year economic impact of the winegrape industry to NC will be $947 million. This includes $40 million in farm gate sales, $300 million in winery sales, $350 million in restaurant/retail sales, and $150 million in tourism. Further expansion of the winegrape industry in the Piedmont region of NC is however limited by Pierce's disease, caused by the bacterium *Xylella fastidiosa*. The bacterium, transmitted by insect vectors from plants growing outside the vineyard, can kill infected vines in 1 to 2 years. Two insects have been confirmed as potential vectors of *X. fastidiosa*, *Oncometopia orbona* and *Graphocephala versuta* and a third, *Paraphlepisus irroratus,* was identified as a potential vector.

b. Impact: Identification of the two primary vectors of *X. fastidiosa* is an important first step in the development of a management plan for Pierce's disease for potential growers in the Piedmont region of North Carolina. We can now more intelligently time insecticide sprays and focus other management techniques such as removal of the reservoir hosts of *X. fastidiosa* where the vectors feed and developing pruning techniques to prevent the establishment of *X. fastidiosa* in vines.

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

Key Theme: Plant Production Efficiency

a. Issue: One of the most successful management strategies for improving yield in corn is the use of increased plant populations. Research conducted over the past 4 years has found that corn yield can be increased by 3 bu acre^{-1} for each 1000 plant increase in plant population. However, to realize this yield advantage growers must find ways to offset decreases in stalk diameter and root mass. Starter fertilizer treatments featuring N and K were shown to result in significant improvements in stalk diameter and increases in root mass compared to an untreated check. Yield increases of 22 bu acre^{-1} were found when these treatments were used. An economic analysis indicated growers could increase profit by $12 per acre.

b. Impact: The number of growers using high population corn systems increased dramatically in 2005. Results in the North Carolina Corn Yield Contest showed that the highest yields came from growers planting 34,000 plants acre^{-1} or more with average contest yield increase of 10 to 20 bu acre^{-1}. County agents in counties where corn is an important crop report that 60% of the corn growers are using higher populations. Given the yield increases experienced by these growers and a corn price of $2.00 per bushel this resulted in an economic gain of $1,200,000 in 2005.

c. Scope of Impact: State and national

Key Theme: Precision Agriculture

a. Issue: Ground- and surface-water nitrogen (N) contamination from southeastern Coastal Plain agriculture is a regulatory and social issue threatening regional crop production. Nitrogen fertility has traditionally been managed on a whole-field basis, which does not take into account soil and crop spatial variability that affects crop N demand and N-use efficiency. NCARS scientists have

developed techniques using aerial color-infrared photography to determine the optimum timing and rates of N fertilization for winter wheat and corn. These techniques are used to determine where in the field nitrogen fertilizer is needed and in what quantity. The remote sensing-based technique recommended a more profitable N fertilizer rate than the current recommendations based on "Realistic Yield Expectations." Another product of this project has been a detailed statistical modeling sequence for the analysis of spatially correlated data that is common in site-specific, variable rate ("Precision") agricultural research.

b. Impact: Using aerial color infrared photography of corn and wheat fields to determine where N fertilizer is needed and in what quantity can help optimize N-use efficiency and improve N fertilizer profitability for producers. Optimizing N fertilization sometimes, but not always, minimized the amount of excess N that can pollute ground and surface waters. The statistical methods developed will have widespread application to the analysis of precision agricultural research worldwide.

c. Scope of Impact: National

Key Theme: Plant Germplasm

a. Issue: Fresh market blueberries usually account for at least 70% of the harvested crop each year in North Carolina, and these have been traditionally harvested by hand. However, labor for hand harvesting is a major uncertainty and may not be available in future years. Therefore, blueberry varieties developed specifically for mechanical harvesting for the fresh market are needed to ensure the survival and continued development of the fresh market blueberry industry in North Carolina. Two southern highbush blueberry varieties, Carteret and Beaufort, adapted to mechanical harvesting for the fresh market were released in 2005. These along with five others varieties previously released, will provide North Carolina with a series of fresh market mechanical-harvest-adapted varieties covering the majority of the highbush blueberry season from very early to late midseason.

b. Impact: The release of these seven varieties adapted to mechanical harvesting for the fresh market means that North Carolina now has mechanical harvest adapted varieties that cover the entire unique marketing niche that our blueberry industry enjoys. The reduced costs associated with harvesting varieties adapted to mechanical harvesting will also keep North Carolina growers in a favorable competitive situation as blueberry industries develop in similar climate zones.

Scope of Impact: State and regional

Key Theme: Invasive Species

a. Issue: Invasive weeds and weeds that have become resistant to currently registered herbicides are an increasing threat to agriculture as well as the natural ecosystems. A number of NCARS research projects are investigating the ecology, impact and management of these weeds. An example includes studies on the seedbank dynamics of members of the Commelinacea (e.g. doveweed and benghal dayflower, a.k.a. tropical spiderwort). These weeds have increased in their distribution and density as they escape the widely relied upon herbicide glyphosate in row crop systems. Other projects have focused on the distribution and management of diclofop-resistant Italian ryegrass, glyphosate and ALS-resistant Palmer amaranth, and glyphosate-resistant horseweed; and the management of Japanese stiltgrass based upon seedbank longevity.

b. Impact: These studies have provided the basis for programs that are widely used by growers in North Carolina for managing invasive and herbicide-resistant weeds and using herbicides in a manner to reduce the selection of resistant biotypes. Homeowners and parkland managers/rangers are currently using recommendations based on these studies for managing Japanese stiltgrass.

c. Scope of Impact: State and national

Key Theme: Plant Health

a. Issue: Plant pathogens, especially viruses, can be transmitted in vegetatively propagated plant materials and cause significant losses. The sweetpotato industry in North Carolina is especially vulnerable to these pathogens. North Carolina growers supply 40% of the total market share of sweetpotatoes in the U.S. with annual farm gate returns of about $53 million. The sweetpotato cultivar Beauregard, grown on approximately 80% of the acreage state- and nationwide is very susceptible to plant viruses including and the russet crack strain of Sweet potato feathery mottle virus (SPFMV). SPFMV alone and/or in combination with other viruses can cause significant reduction in yield and quality of sweetpotato storage roots. The Micropropagation Unit (MPU) at NCSU has developed and implemented certification program for sweetpotato in collaboration with N.C. Crop Improvement Association, Inc., N.C. Foundation Seed Producers, Inc., and the departments of Plant Pathology, Horticulture and Entomology. The MPU produces and maintains in vitro Nuclear Source tissue culture plants of 15 sweetpotato cultivars that are virus-indexed, free of known pathogens and true-to-type and are used by certified nurseries in North Carolina to produce Elite, G1 and G2 planting stocks.

b. Impact: The sweetpotato certification program has contributed to the continuing sustainability of the sweetpotato industry in North Carolina, and has improved the overall quality of planting stocks and the commercial crop. Over 80% of the sweetpotato acreage in North Carolina is currently planted annually with planting stocks derived (directly or indirectly) from the MPU. Growers estimate that use of certified plants has increased yields by 20%.

c. Scope of Impact: Regional and national

Key Theme: Plant Genomics

a. Issue: Rice provides the major caloric intake for more than half the world's population. Thus factors that limit rice yield, such as disease, are of special concern. One of the most devastating diseases of rice and related grasses is caused by Magnaporthe grisea, known as the rice blast pathogen. Scientists at NCSU have led a consortium of rice and rice blast researchers working to dissect the molecular basis of plant disease that will lead to improved crop productivity. The genome sequence of both rice and rice blast has been decoded.

b. Impact: Sets of genes with defects in pathogenicity and several others in growth, pigmentation, and sporulation of the rice blast fungus have been identified. Using microarrays, entire suites of genes differentially expressed during infection-related morphogenesis, carbon and nitrogen starvation, and invasive plant growth have been identified. Using directed gene knockouts, novel genes were identified that are involved in the infection process. To support these studies MGOS, a web accessible database that is populated with sequence, mutant, and microarray data was created.

c. Scope of Impact: National and international

Key Theme: Adding Value to New and Old Agricultural Products

a. Issue: To increase the profitability and ability of North Carolina tree fruit growers to compete in a global market it is necessary to increase fruit quality, achieve consistent annual production, maximize productivity and reduce inputs and add value. In addition, NC growers must diversify their markets to remain competitive and profitable as well as producing value-added products. Research conducted by NCARS scientists over the past 4 years has evaluated strategies and products to control browning for fresh sliced apple industries. In addition, research has been conducted to address major horticultural issues limiting tree fruit production in the Southeast.
b. Impact: During 2005, a new commercial business was launched in Henderson County that heavily involved NCCES and NCARS specialists, agents, and researchers, with all plans, management, and technical details established, for a January 2006 ground breaking for construction of a $ 2.5 million state-of-the art apple slicing facility. This business will begin operation in May 2006 and will add approximately 20 new employees. This plant will provide apple slices for the retail market, one of the fastest growing fruit markets nationally. The economic benefit to the apple growers, processor and citizens of Henderson County will be significant from the number of new jobs created as well as economic input into the local economy. In addition, the increase in consumption of fresh apples, high in antioxidant anti-cancer properties, will benefit the entire Southeast with healthier diet choices in a snack food package.

c. Scope of Impact: State and regional

Key Theme: Organic Agriculture

a. Issue: Sweetpotato is North Carolina's most important vegetable crop. In 2004, 45,000 acres valued at $93 million were grown in NC, more than any other state in the nation. Botran, a fungicide used to control postharvest diseases, is no longer tolerated by the baby food industry. Sweetpotatoes are Gerber's top baby food product and approximately 15% of NC's sweetpotatoes are sold to this market. Likewise, export markets in the EU have banned the import of sweetpotatoes with Botran residues. This export market is lucrative and the demand is growing rapidly. Through a series of studies over the course of 3 years, four products that control Rhizopus soft rot at or near the level of control achieved with Botran were identified: two biological control products Bio-Save 10LP & 11L two reduced-risk fungicides Scholar (a.i.=fludioxonil) and Pristine (a.i.=pyraclostrobin+boscalid).

b. Impact: Bio-Save is now labeled for use in NC and several packing lines are using this biological control agent for their export markets in the EU. Scholar and Pristine are in the process of getting registered for use on sweetpotatoes through the IR-4 minor crops pesticide use program. Both products are considered reduced-risk compounds because of their low toxicity to mammals and other non-target organisms and well as their impact on the environment.

c. Scope of Impact: State, national and international

Key Themes: Livestock Systems

Key Theme: Adding Value to New and Old Agricultural Products

a. Issue: Aquaculture is one of the most rapidly expanding sectors in agribusiness worldwide. At the same time, traditional fish farming methods limit the growth of aquaculture in North Carolina and around the globe because of limited water supplies and concern for environmental impacts of this "animal agriculture" activity. Recirculating aquaculture production technology is used to produce fish in tanks by cleaning the fish waste from the water and using the water over and over again. While these fish production systems are often viewed as "green" technology, if their effluent is not treated, nothing is gained and in-fact more environmental damage can be done as their waste stream is focused into a single high-strength point discharge. The North Carolina Fish Barn program has been active in the development and dissemination of recirculating aquaculture production technology since 1990. The resulting technology combines water treatment components from around the world to allow for production of freshwater and marine finfish in tanks with very little water usage. Major advancements were made in the development of wastewater and solid waste treatment from this production technology. The goal of this project was to reduce the organic solids load of the waste stream leading to the effluent holding pond. What has actually been accomplished is a waste reduction so complete that it may soon be possible to completely re-use the wastewater in the production system.

b. Impact: For the foreseeable future, farmers will land apply the water from this process. However, after further testing at the NC State Fish Barn, reuse of the water will save the farmers a significant amount of money by reducing the loss of salt, bicarbonate and heat that would be discharged in the effluent. We estimate these savings in salt and bicarbonate purchases alone could amount over $2,000 per month per farm.

c. Scope of impact: State specific

Key Theme: Agricultural Competitiveness

a. Issue: The purpose of the North Carolina Layer Perfo[illegible]de strain evaluations in under common husbandry and environmental conditions to the producers in North Carolina. This is the only test of this type and size remaining in the world. This project has expanded to develop and to provide scientific answers to issues relating to hen welfare, behavior, molting practices, egg processing, and beak trimming practices facing the egg industry. Much of the behavioral research in this program centers on the practice of molting, which is widely used in the egg industry, and in turn has helped industry organizations establish applicable animal care guidelines. This program deals with egg production type chickens in the production environments and to provide insight as to the well-being of the laying hens under different cage densities and husbandry practices (molting). We have been examining alternative molting programs for their effectiveness as related to the industry standard program of fasting. These experiments included a survey of the microbial shedding of laying hens subjected to alternative molting programs. In addition, the integration of an egg solids study, for the breaking industry, along with functionality and egg safety studies were recently completed.

b. Impact: The NCLP&MT reports are sent to all the producers in North Carolina and an additional 330 reports are sent to producers and industry representatives throughout the US and 16 different countries. The primary breeders, egg producers, and egg breaking companies are utilizing the test in

increasing intensity to compare and evaluate the impact of strain, environment, and management have on the egg solids, functionality, and safety. This can lead to a shift in layer strain purchases on the part of the breaking companies to enhance their product properties thereby enhancing sales to egg product purchasers. The breeders have increased their support to cover some cost of the research, and all publication, and postage.

c. Scope of Impact: national

Key Theme: Agricultural Competitiveness

a. Issue: Present waste management systems used for swine farms in North Carolina have been under attack by environmental groups and the media. The political climate has moved toward more regulation of animal farming regarding odor control and nutrient management. Evaluation of present and alternative swine waste management systems is critical to the continued vitality of the swine production industry and protection of our environmental resources in North Carolina. North Carolina State University has conducted evaluations of on-farm demonstration projects for innovative swine waste treatment. Six projects were selected from forty-two proposals that were submitted by the technology providers and reviewed and rated by a diverse panel. NCSU was designated to provide technical and economic evaluation of the technologies. Several of those projects have had field days to transfer information to Cooperative Extension Service agents, swine producers, consultants, and others. The high level of interest in these projects from various persons within and outside of N. C. has resulted in numerous opportunities for answering inquiries, providing information, hosting visitors, and making presentations. Furthermore, the results have been presented in national symposia and journals to make the information available to the various groups that are highly interested in swine waste treatment and utilization.

b. Impact: With high public and political interest in swine waste management, and the possibility of much misinformation from self-interest groups and unrealistic expectations from legislators and regulators, it has been very important to accumulate and present factual and unbiased information. Efficient and professional execution of these projects has enhanced our reputation of being a leader in technology development and environmental protection.

c. Scope of impact: national

Key Theme: Agricultural Profitability

a. Issue: Pork quality is one of the main issues of concern for the pork industry in the U.S. It was reported in the Pork Chain Quality Audit that total cost per pig from color and Pale Soft and Exudative meat (PSE) related problems were $1.05. Of this amount, $0.79 per pig was estimated to be directly controllable by pig producers. In an industry that produces 88 million swine annually, this amounts to a total of $69.5 million in losses due to pork quality problems. These numbers may be an underestimate considering some packing plants in North Carolina have reported that up to 40% of the pigs they process have PSE related problems during the summer. The main quality concerns identified by all members of the pork marketing chain are poor color and inadequate water holding capacity. Therefore, addressing these quality traits is of great priority to increase the market value of pork and to provide consumers with a desirable product. We evaluated whether Mg supplementation through the water would impact pork quality in pigs. We determined that supplementation for as short as two days could impact pork quality, regardless of dose of supplementation. We were able to

demonstrate large differences in pork quality between genotypes, but did not detect effects of Mg on pork quality in these genotypes. From our studies, we determined that the effects of Mg on pork quality vary and cannot be explained by variation in growth rate of pigs or genetic predisposition to poor pork quality. Currently, efforts are ongoing to evaluate the potential impact of Mg supplementation on pork quality under commercial conditions and at several commercial packing plants.

b. Impact: Water supplementation of Mg can be easily implemented on farm, is relatively cheap, and appears to be effective in improving pork quality after a very short supplementation period. Based on the estimates reported above, improved product quality can have a value to producers of maximal $0.79 per pig ($70 million in the U.S). This value would be directly related to improvements in market share of pork products.

c. Scope of impact: national

Key Theme: Agricultural Profitability

a. Issue: Aquaculture continues to be a fast-growing segment of agriculture in the United States and in North Carolina. Farmers are anxiously looking for opportunities to diversify existing operations, and current aquafarmers continue to look at expansion, increasing profitability, and developing commercial culture methods for new species. Reclassification of properties for tax purposes has caused some farmers to examine formerly unproductive land and reconsider new activities such as aquaculture for that land. Environmentally responsible management of wastes produced by aquaculture operations must be an integral part of the development and expansion of aquaculture, while at the same time, the management of these wastes must be economically feasible for these operations. The State of North Carolina has invested in the personnel to assist those in our state who wish to develop aquaculture businesses. Considerable time and money has been invested in the development of trout, catfish, hybrid striped bass, shellfish, yellow perch, Southern flounder, and ornamental fish as components of our agriculture. Most recently, however, we have begun to support activities in water re-use systems, or recirculating aquaculture. This type of aquaculture can be located in water-limited areas of our state, and represents the potential for a more controlled environment for the culture of aquatic organisms. Commercial operations have been developed that are now beginning to expand production, refine production methods, and develop culture methods for new species of finfish.

b. Impact: By assisting in the planning, construction, startup, and operation of new aquaculture facilities, we can help improve the possibility of success for new operations. Being available with the necessary resources and technical knowledge will encourage otherwise hesitant potential aquaculturists to form new businesses. Formation of new businesses will occur, as well as strengthening of existing businesses through diversification of operations. New ways may be found to help preserve the family farm that has long played an important role in North Carolina. Development of these new businesses will result in a broadening of the tax base and strengthening of our economy. In addition, by demonstrating better methods of handling the waste generated by recirculating aquaculture operations, we can assure that new and existing operations can develop without being viewed as damaging to the environment, thus positioning them for better acceptance in their respective communities throughout North Carolina.

c. Scope of Impact: State specific

Key Theme: Agricultural Profitability

a. Issue: Profitability in the dairy industry is modest and volatile. Feed costs represent over half of the cost of producing milk, so controlling feed costs is essential. This depends on precise feeding strategies to supply needed nutrients without wastage, wise use of least-cost feeds, efficient feeding operations, and diets that support optimum production, health, and reproduction. Dairy producers must devise an optimum feeding program, evaluate feeds and feeding systems, and appraise the performance of the feeding program. North Carolina Cooperative Extension provides an educational program in dairy cattle nutrition to dairy farmers and the dairy industry. Information includes the selection and use of feeds, feeding strategies, diet formulation programs, and the effect, prevention and treatment of mycotoxins. The State of North Carolina operates a feed analysis program for farmers to determine nutritional value and contamination with mycotoxins. Computer feed formulation programs are provided to the industry. Nutrition and feeding recommendations are supported by research at North Carolina State University. Cooperative Extension specialists and agents provide the latest information to dairy producers and the feed industry.

b. Impact: Ration formulation using alternate feeds and based on feed analysis has increased annual dairy farm profits by $100 per cow. Over 80 percent of North Carolina dairy producers are using these feeding recommendations. These adopted feed practices are estimated to annually benefit the North Carolina dairy industry by $10 million. They have also improved the safety and quality of North Carolina produced dairy products.

c. Scope of impact: state specific

Key Theme: Animal Genomics

a. Issue: Termites are major structural pests, causing billions of dollars in damage annually across the U.S. including North Carolina. Newer, more ecologically sound methods of control, such as baiting technologies and limited treatments with non repellent liquid termiticides, are being developed. The success of the new technologies will depend on a sound understanding of termite the social and spatial organization of termite colonies. Because of their highly cryptic nature, it has been difficult to obtain detailed information on colony social and spatial structure. Using molecular genetic markers to map the locations of colonies infesting and surrounding homes in Central North Carolina, researchers at North Carolina State University have found that many homes have may up to three colonies actively infesting a house simultaneously, may have numerous colonies within 50 ft. of the foundation, and may have up to 100 colonies per acre in the yard.

b. Impact: These studies show that termite treatments limited to a small area of a structure may not effectively protect it against attack by subterranean termites.

c. Scope of Impact: state specific

Key Theme: Animal Genomics

a. Issue: Male broiler chickens exhibit superior agro-economic characteristics when compared to females. Therefore it is desirable to produce a disproportionate number of male offspring. In birds, gender is determined by the female which produces ova bearing a Z or W chromosome in equal

proportions. Male birds produce only Z bearing sperm. The embryonic transfer of male primordial germ cells (PGC) to female recipients increases the potential of male offspring. There appears to be a negative correlation between bird age and gonadal PGC numbers in White Leghorn (WL) chickens. On average, PGC numbers in WL males declined by nearly 35 cells per week. In a preliminary trial, we utilized fluorescent activated cell sorting (FACS) to evaluated gonadal PGC populations in WL male embryos from flocks with hen ages of 37 or 94 weeks, respectively. Embryos from the "younger" flock exhibited mean gonadal PGC numbers of 473/embryo. Conversely, only 126 PGC/embryo were observed from the "old" flock. This represents nearly a 4X differential. These data further support the hypothesis that gonadal PGC numbers decline with hen age. Male gonadal PGC transferred to female recipients failed to produce sufficient numbers of germline chimeras or donor derived offspring. The specific biological hurdles may involve: a) an inability of male gonadal PGC to re-migrate to the female gonad or b) a failure of male gonadal PGC to adequately divide within the female environment. In addition, male gonadal PGC may be committed to a specific path of development that does not allow for the formation of ova. Barred Plymouth Rock (BPR) PGC were injected into WL embryos. After we determined that BPR embryos possessed nearly 70% fewer endogenous PGC than those observed in WL, we began to utilize WL as donors and BPR as recipients. The assumption was that a greater likelihood existed the lower number of endogenous germ cells in BPR embryos would allow better colonization of the embryo.

b. Impact: Gonadal primordial germ cell numbers appear to be associated with genetic strain, gender, and hen age. Fluorescent Activated Cell Sorting analysis of primordial germ cell populations may serve as a selection tool for use in the development of specific table egg strains or to predict reproductive performance in commercial meat lines of broilers and turkeys. This assumes that primordial germ cell numbers are correlated with adult egg production as would be suggested by the comparison of White Leghorn and Barred Plymouth Rock chicken data.

c. Scope of impact: State specific

Key Theme: Animal Health

a. Issue: Broiler chicks and turkey poults are most susceptible to enteric disease, primarily because of compromised feed digestion and malabsorption during the first 2 weeks after hatch. Early gut health problems account for about 5% of the total flock mortality, and it may have lasting effects on disease resistance until the birds are harvested. Nutritional factors that influence early enteric health and nutrient utilization include: stabilizing the microbial ecosystem of the gut, improving feed digestibility and nutrient absorption; and properly balancing dietary nutrients relative to requirements for optimum growth and development. As dietary nutrient utilization is improved, the environmental impact of mineral emissions from concentrated poultry operations will be reduced. Research and extension education efforts were done to develop and demonstrate nutritional strategies that improve the efficiency of dietary nutrient utilization and enhance enteric development of young poultry. 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. Enteric development was accelerated 48 hr after in ovo feeding, such that the *in ovo*-fed chicks and poults had significantly advanced capacity to digest and absorb nutrients during the first week after hatch. In *ovo* feeding improved hatchability and energy status of hatchlings, and it increased appetite and early growth rate by 3 to 10% over controls. Breast muscle development of chicks and poults was also improved, especially if they were given ad libitum to feed.

b. Impact: This basic research on in ovo feeding has lead to industry development grants totaling over $2 million during the last year. These funds will be used to develop in ovo feeding formulas and an automated delivery method for commercial applications. Knowledge gained from the in ovo feeding project has resulted in changes in hatchery management and breeder nutrition to enhance the survival of broilers and chicks, and nitrogen emissions, better nutrient utilization, and improved enteric health.

c. Scope of impact: state specific

Key Theme: Animal Health

a. Issue: Enteric disease and enteric viruses are a major cause of morbidity and mortality in agriculturally important species and in humans. Losses to enteric diseases in poultry can be significant, as demonstrated by the emergence of Poult Enteritis Mortality Syndrome (PEMS) in the 1990s. Enteric diseases can cause high mortality, but their economic impact is often more evident in the inhibition of growth and poor feed conversion. Understanding how these pathogens cause disease is imperative to understanding how to prevent, treat, and control enteric disease and promote animal health. Turkey astrovirus type-2 was isolated from turkey poults affected with PEMS. Subsequent studies have demonstrated it is associated turkey flocks suffering from enteric disease which do and don't meet the clinical definition of PEMS. Data from our laboratory indicate that the innate immune system may play a critical role in controlling the replication of this virus in young naïve poults. Molecular characterization and comparison of numerous field isolates of TAstV-2 suggest possible evolutionary changes and selection pressures and will hopefully lead to identification of potential vaccine strains.

b. Impact: These studies will help us understand how enteric viruses cause disease in poultry through identifying the physiologic and cellular changes which occur following TAstV-2 infection. This model will also demonstrate how immunologically immature animals are capable of defending themselves from viral challenge. This discovery will allow us to develop non-vaccine based therapies which would be less costly to produce, easier to administer, and have a more broad spectrum affect than current strategies for protecting poultry from viral infection. Additionally, this model will also lead to important advances in our understanding and treatment of infants infected with the human form of astrovirus, which suffer similar disease and age distribution. Studies of astrovirus infected infant intestinal biopsies by other researchers have described their findings to be very similar to those we reported in experimentally infected turkeys.

c. Scope of Impact: state specific

Key Theme: Animal Health

a. Issue: Intestinal infections represent the largest group of diseases that adversely affect poultry production. The increasing pressure to eliminate antibiotics and probiotics in poultry production as well as the constant appearance of new intestinal diseases in poultry, both of bacterial and viral origins, demands the development of new means of prevention and treatment. Probiotics, or live direct fed microbial supplements, hold great potential for offering a safe and efficacious alternative to traditional medicines. Unfortunately, scientists have not developed an integrative understanding of the mechanisms of action of probiotics. Development has largely been conducted on a trial and error basis. We have endeavored to develop an integrated understanding of the mechanisms of actions of

probiotics in poultry to assist in development of a rationale method of designing these live microbial feed supplements. We have been the first to determine that the use of probiotics decreases by 17% the amount of energy needed by the broiler to grow. The increase in the efficiency of use of feed by the broiler is likely due to decreased immune system activity and the need for energy by the intestinal tract (as much as 57%). These findings mean that energy normally used to fight pathogens and maintain intestinal integrity are used for meat production by the broiler.

b. Impact: The estimated total market for annual sales of poultry health products is $3.2 billion per year. The estimated cost of poultry medicines is $650 million per year. These costs are obviously driven by the need to prevent and treat poultry diseases, especially those of the intestinal tract. The development of probiotic feed supplements that are effective would greatly reduce these costs, resulting in lower production costs and lower consumer costs.

c. Scope of impact: state specific

Key Theme: Animal Production Efficiency

a. Issue: Improved hatchery management. There are hundreds of thousands metabolically active embryos growing in the incubators of a hatchery. The environment these eggs are exposed to need to include an optimal temperature, humidity, oxygen and carbon dioxide environment, and egg orientation. The environment however is extremely variable because of egg shell properties, embryonic metabolic rate, the physical constraints of the hatchery building, and the type of management imposed upon the eggs within the incubators. Additionally, recent genetic selection for specific attributes in the processed broiler to meet specific market needs has also created a challenge to the hatchery manager. Research is being conducted at NC State University to determine the physiological response to the temperature, humidity, oxygen and carbon dioxide environment, and egg orientation. Research at NCSU has demonstrated that because of increased selection pressure for economical traits the conditions used to incubate hatching eggs need to be altered. Our work has demonstrated how maturation of organ systems that impact performance can be altered by manipulation of incubation parameters. Educational material has been developed and used in the NCSU Hatchery Management Workshop as well as other educational efforts.

b. Impact: This effort allows the hatchery worker to increase their knowledge with respect to how their management influences the physiology of the embryo and hatchling and thus influence how the hatchling performs in the field. This programming allows them to understand what is happening with regards to the developing embryo and how to use the information, and the data they collect to take appropriate action for improvement through the quality process when the results are outside of expected standards. The research being conducted will allow changes to be made to management.

c. Scope of Impact: state specific

Key Theme: Animal Production Efficiency

a. Issue: The US swine industry (including NC producers) have adopted production practices on a large scale which involve early-weaning of piglets at 18-21 days of age. The younger and lighter piglets in this scheme exhibit reduced survival rates and slowed growth. Among the many stressors impacting these pigs is the abrupt switch from liquid feed (mother's milk) to dry feed. We have worked to develop and test feeding systems which supply feed to the newly-weaned pigs in liquid

form (i.e., manufactured liquid diets). These systems are designed for ease of operation and cleaning so they may be easily adopted on a large commercial scale. A remaining challenge to implementation of liquid feeding of young pigs is the relatively high cost of commercial milk replacers. Our recent studies have documented superior growth performance of pigs fed milk diets formulated using lower-cost vegetable proteins compared with high-cost milk proteins (casein & whey).

b. Impact: We have documented superior growth performance of piglets reared using liquid-feeding systems. Indeed, pigs reared with this new technology can grow at twice the rate of sow-fed siblings. We also have documented that the improved growth early in life translates into fewer days to market weight and anticipate that significant economic returns may be achieved when these systems are employed, provided diet ingredient costs are managed properly. The incorporation of lower cost ingredients (such as processed vegetable proteins) represents a significant step in this direction.

c. Scope of impact: State specific

Key Theme: Animal Production Efficiency

a. Issue: Like most vertebrates, reproductive performance of turkey breeder hens is adversely affected during the hot summer season as compared to the winter season. Egg production in the summer may be reduced by 20-40% of that occurring during the winter. Any correction to this egg loss would have substantial economic benefits. We have just completed a study of improved lighting management for turkey hens photostimulated to lay eggs during the summer season. In short, the results support a conclusion that breeder hens may typically be receiving insufficient light each day. Hens receiving 18hr of light per day as compared to the typically used 15 hr per day, produced about 11 more eggs per hen during 24 wk of photostimulation.

b. Impact: An increase of 11 eggs per hen during the summer has considerable economic benefit and goes a long way in improving the consistent production of turkeys on a year-round basis. Fertility of turkey eggs is expected to exceed 85% and each fertile egg costs about $.75. If 9 of the 11 extra summer eggs are fertile there would be a $6.75 per hen added value and in North Carolina we have about 3.0 million breeder hens.

c. Scope of impact: state specific

Key Theme: Animal Production Efficiency

a. Issue: With a constant effort to improve production efficiency and because of the high usage rate of nipple drinkers by broiler producers, the turkey industry currently has an interest in testing nipple drinkers as an alternative to traditional open drinker systems for rearing commercial turkeys. Nipple drinkers offer advantages over the traditional systems including cleaner, less contaminated drinking water, drier litter which reduces pathogen load, as well as less labor because nipple drinkers do not have to be cleaned. However, there is a concern that nipple drinkers systems might not be able to supply enough water for maximum growth of commercial turkeys. Therefore, the purpose of these studies was to test the efficacy of nipple drinkers for rearing turkeys. In trial one, Large White commercial toms were grown to 20 weeks of age in 48 pens. There were 6 different drinkers tested including the control and 5 nipple drinker systems. The control was the Plasson Turkey Bell and the nipple drinker systems tested were the Plasson Easy Start, Valco Turkey Drinker, Lubing Traditional (commercially known as FeatherSoft® high flow nipple with Littergard®), Lubing Easy Line, and

Ziggity Big-Z Activator. Body weight, feed conversion, and feed consumption were measured through out the study. In trial two, Large White commercial hens were raised to 20 weeks in 48 pens. All variables and procedures were the similar to those in the tom study. Litter moisture was measured beneath the drinker at 6 and 20 weeks in trial one only. In trial two, litter cake was removed and weighed by pen.

b. Impact**:** Nipple drinkers were found to have a significant effect on body weight. Birds on nipple drinkers had reduced body weights, particularly during the time of most rapid growth. Feed conversion was not initially effected by drinker type. Feed consumption was not reduced by nipple drinkers until the last period of the first trial. Feed consumption was reduced for some systems throughout trial two. Litter moisture beneath the drinkers in trial one was affected at 6 and 20 weeks. Some drinker systems resulted in lower litter moisture while others resulted in higher litter moisture. The results of this study concur with the results of other studies that were similarly conducted. Nipple drinkers can be an alternative to traditional open watering systems particularly during the brooding period up until 6 weeks of age. Some systems can be used to rear turkeys all the way to market age. In addition, a combination of nipple drinkers during brooding and open watering systems during grow-out may also be successful. The results of this research will allow turkey producers to make informed decisions about using nipple drinkers for turkey rearing.

c. Scope of impact: state specific

Key Theme: Aquaculture

a. Issue**:** 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. Wholesale prices for fresh flounder range from $5-$10 per pound so the economic potential for cultured flounder is promising. Because their range of distribution extends from North Carolina along the Atlantic and Gulf coast into Mexico, the potential for culture in a large geographic area exists. We aim to demonstrate and transfer practical culture methods for the fingerling and foodfish production to the first commercial producers of southern flounder in the U.S. We have succeeded in the establishment of XX males for use in producing all-female fingerlings. Our research has also established the first commercial-scale data on growout characteristics with a full economic analysis of the results. These accomplishments are fundamental steps in the commercialization of flounder culture and will lead to maximizing the economic viability of flounder farming.

b. Impact: The establishment of Southern flounder as a new, high-value aquaculture species represents the first introduction of a fish with a worldwide market appeal and the capability of being cultured over a large geographic area. We see the potential for flounder culture as equal or superior to that of the hybrid striped bass industry, which has enjoyed a growth rate of 20 percent per year for the past 10 years and the achievement of an annual farm-gate value of more than $5 million to North Carolina alone. The economic potential of flounder farming in the United States could reach five-to-10 times the value of the hybrid striped bass industry within the next 10 years.

c. Scope of Impact: national

Key Theme: Diversified/Alternative Agriculture

a. Issue: A long-term dairy grazing study at NCSU conducted in the 1990's resulted in a series of refereed publications and numerous articles in popular press and conference proceedings. Those results demonstrated that although pasture-based dairy production may result in less milk per cow that there were enough efficiencies gained otherwise to be economically competitive with confinement feeding systems. Producers have inquired about ways to reduce costs or to add value to their farm enterprises by on-farm processing, or possibly converting to organic production. Current work with pasture-based dairy research at the Center for Environmental Farming Systems is adding additional knowledge to the opportunities for pasture-based dairying in North Carolina including information on use of crossbred dairy cattle in such production systems.

b. Impact: Although improved grazing systems are used on a small percentage of farms, there is increasing interest in use of pasture as a basis for entry into organic production. There have been a number of inquiries about the possibility of organic dairy production in North Carolina and a group of specialists and others are working to provide objective information for producers considering that option. A national dairy cooperative, Organic Valley, has offered support to help interested dairy producers to transition into organic production. Several dairy producers are now considering organic dairy production as an option. In the past several years there have been 14 dairy farms that have been assisted as they developed plans for on-farm processing of fluid milk and ice cream or production of fresh and aged cheeses in North Carolina.

c. Scope of impact: State specific

Key Theme: Diversified/Alternative Agriculture

a. Issue: Biological control is a tool used in Integrated Pest Management (IPM) programs in both "conventional" and "organic" agriculture that can reduce the use of pesticides and their side effects. Organic farmers in particular, have a dire need for research directed at understanding the population dynamics of pest insects as well as the role of beneficial insects in their cropping systems. Organic farmers have stated in surveys that insect pests are their number one problem, and the top research needs to address the problem were beneficial insects and beneficial insect habitat. Implementation of existing biological controls is also limited by the lack of general public knowledge regarding biological control and it's effective use. Comparisons of insect populations and damage were made between organic and conventional cropping systems. Evaluations of beneficial insect habitat use on organic farms have been made. Evaluations of beneficial organism releases on organic farms were conducted. Workshops and training on these subjects was provided to audiences across the state, and was very well received by members of the organic and sustainable agriculture community.

b. Impact: Studies of commercially available beneficial insect habitat seed mixes have provided growers with much needed guidance on whether to use these products, and if they choose to, how best to plant them. A simple, easy to use method was implemented to dramatically increase the lifespan of parasitic insects released for insect pest management. Ongoing work comparing insect populations in organic and conventional cropping systems will provide organic growers with sorely needed information on insect management. The ongoing studies on beneficial insect habitat will also provide organic growers guidance on how to select habitat plants to improve their insect management systems. Extension and outreach programs and materials in biological control have been delivered to a large number of individuals in a variety of client groups.

c. Scope of Impact: state specific

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

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 intensified 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 systems 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:

- As a result of work on peppers, processors are now aware of a previously unrecognized mechanism that could cause rapid loss of quality of their products. The demonstration that sulfite prevents oxygen-mediated softening provides a practical means to prevent this type of quality loss.
- Transgenic lines of peanut were developed that carry a transgene encoding ‘Mod 1’, an active form of the ribosome inactivating protein ‘Mod 1’ from maize, and shown to be resistant against *Aspergillus flavus* infection, *Sclerotinia minor,* and *Sclerotium rolfsii*.
- Genes involved in ethylene biosynthesis, signaling, and response have been identified and characterized in the plant model system *Arabidopsis thaliana.* Once the function and regulation of these ethylene-related genes are understood, the *Arabidopsis* genes or their orthologues from other organisms can be introduced into agriculturally significant species to alter their ethylene production or sensitivity, with the ultimate goal of crop improvement (i.e. higher yields, better appearance and longer lifetime of fruits and flowers, etc.).

Performance goal 2, which ensures that food products are free from toxic contaminants, has been addressed by:

1) NCSU researchers have developed methods for the computational assessment of the toxicity of chemical mixtures. These methods will be of use to environmental managers in assessing the health risks associated with chemicals in the environment.

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

- Proper chilling of fish on-board the boat was studied to determine the prevalence and type of spoilage bacteria capable of producing histamine. Studies are underway to determine the effects of high hydrostatic pressure treatment on bacteria and enzymes responsible for histamine formation.
- Researchers at North Carolina State University have identified three egg shell membrane-bound proteins (β-N-acetylglucosaminidase, lysozyme and ovotransferrin) that work in concert to alter the normal functioning of bacterial cell membranes of several foodborne disease causing organisms (*Salmonella, Staphylococcus, Listeria, E. coli*) resulting in a significant increase in their sensitivity to heat treatments.
- There are an estimated 2.5 million cases of campylobacteriosis in the U.S. annually, with a cost of infection between $1.2 and $1.4 billion. NCSU researchers are developing specific inhibitors of C. jejuni that could safely be used in food animals, thereby reducing the level of C. jejuni contamination in the food supply.
- NCSU researchers have demonstrated that novel, inexpensive concentration schemes can be combined with nucleic acid amplification methods to provide reliable assays for the detection of many pathogens in a wide variety of foods. Ultimately, this means that we are approaching a time when the routine "real-time" detection (i.e., confirmed detection in less than 8 hours) of pathogens in contaminated foods may become a reality.
- A system was developed for determining the specific killing effects of organic acids on the survival of microbial food pathogens including Escherichia coli 0157 :H7. An unexpected result was obtained: several organic acids exhibited protective effects at low concentration, opening an entirely new area of research.

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
$305,009	$2,780,712	$788,538	$624,374	13.24	54.47	41.84	2.78

Key Theme: Food Quality

a. Issue: Scombrotoxic fish poisoning is one of the three leading seafood-borne diseases in the United States. Reducing the risk caused by consumption of temperature-abused fish requires intervention strategies from point of harvest through processing and distribution to point of sale and consumption. Time and temperature are the primary measures used to control formation of biogenic amines in susceptible fish species responsible for the disease. But high hydrostatic pressure treatment is another measure being evaluated for the control of toxigenic histamine-producing bacteria and scombrotoxin formation.

b. Impact: Proper chilling of fish on-board the boat was studied to determine the prevalence and type of spoilage bacteria capable of producing histamine. This information was compiled and incorporated into model seafood safety plans for use by commercial and recreational fish harvesters. The information along with current regulatory guidelines is posted at http//:www.iceyourfish.seagrant.org. In addition, workshops are available through the various Cooperative Extension and Sea Grant offices. Currently, work is underway to determine the effects of high hydrostatic pressure treatment on bacteria and enzymes responsible for histamine formation. The use of proper time and temperature controls and application of pressure processing is likely to reduce or eliminate the risks to acceptable levels in fish products.

c. Scope of Impact – National

Key Theme: Food Safety

a. Issue: North Carolina is the second largest trout-producing state in the US. North Carolina trout farmers as well as trout farmers across the country produce a wholesome and safe product, but consumers are constantly bombarded with conflicting information regarding seafood safety, resulting in difficulty making wise and healthy choices regarding fish consumption. The correlation between fish consumption and mercury is one example of conflicting information that could result in consumers avoiding seafood in spite of clearly demonstrated health benefits obtained from eating fish. Farmed fish, and farmed trout in particular, have extremely low levels of any contaminants, but only limited information is available relative to mercury content in these products.

Beginning in 2005, an Aquaculture Specialist at NCSU designed and coordinated an effort to obtain samples of farm-raised rainbow trout from commercial facilities in the primary trout production states across the US. The sampled trout were ready for market and were from 12 to 18 months of age. Information was also gathered about the feed sources, water supply, and proximity to any potential source of mercury discharge, such as waste sites or coal-burning industries. The trout samples were then analyzed for mercury content, using samples of edible muscle tissue only since methylmercury accumulates in those tissues rather than in fat, skin or internal organs. In every case, the mercury content of the farmed trout was orders of magnitude below the action limits set by FDA (1.0 ppm) or by EPA (0.3 ppm). Average mercury content in trout meat was 0.013 ppm with a range from <0.001 to 0.030 ppm in all samples, placing it among the very lowest in popular seafood species. There was no difference between locations or facilities, and all samples were actually below the legal reportable limit for the analytical method used (EPA Method 7470A; legal reportable limit 0.05 ppm).

b. Impact: When a processor or producer is asked, "how much mercury is in your fish", the answer cannot be "I don't know" or "we haven't checked" or the potential customer is lost. Public perception resulting from negative and conflicting reports on the safety of fish consumption relative to mercury

content has resulted in a decline in consumption of some fish products, for example, a >10% drop in tuna consumption nationally. Trout producers now have additional evidence to document the safety of their product and avoid the costly impacts of consumer fears regarding mercury. The value of this information to the industry is difficult to assess, but the potential cost of lacking the information could be devastating.

c. Scope of Impact – National

Key Theme: Food Quality

a. Issue: NCSU researchers and extension specialists have established an entrepreneurial assistance program for value-added seafood products to include the three areas of agricultural research; production, processing and distribution. So far, many individuals and four firms have participated with special emphasis placed on technical and informational assistance to develop value-added fishery products. Current efforts are focused on fresh water fish and include catfish, hybrid striped bass, tilapia, rainbow trout and yellow perch. New value-added products developed include smoked trout pate, 12 trout stuffings, chilled salads, dips, smoked fish and pasteurized crab meat.

b. Impact: The impacts of these efforts are improved product quality and development of value-added products by North Carolina farm-raised fish producers. The economic benefits of introducing value-added products into the marketplace are important to the growers. By expanding into niche markets for value-added products, entrepreneurs and small processing firms are able to add additional revenues to their bottom line.

c. Scope of Impact – North Carolina and National

Key Theme: Food Security

a. Issue: Foodborne disease is increasingly recognized as an important public health issue, with current estimates citing as many as 76 million cases per year with up to 9000 deaths. Since the events of September 11, 2001, the potential for food bioterrorism also has received significant attention. Development of rapid detection methods for foodborne pathogens is a critical need if we are to adequately address both public health and homeland security issues associated with food safety. Unfortunately, most pathogen detection methods are designed to test for a single organism per assay. Furthermore, the pathogen(s) of concern are usually anticipated before applying the detection method, meaning that it is difficult to screen samples for multiple, "unknown" pathogens. To facilitate effective screening of foods for intentionally added pathogens, an assay is needed that can detect the most relevant foodborne pathogens in a single test.

The purpose of this research was to develop a test that would be able to detect multiple foodborne pathogenic organisms simultaneously and using a single assay. The general approach uses a "universal" molecular amplification followed by identification of specific pathogens using gene probes designed in a reverse hybridization array format. Target pathogens are E. coli, Salmonella, Listeria monocytogenes, Vibrio vulnificus, Shigella flexneri and Staphylococcus aureus. The assay is highly specific and sensitive, with little cross-reactivity and demonstration of detection limits as low as 1-10 organisms/mL.

b. Impact: We have developed a prototype method to detect multiple foodborne pathogens and demonstrated that it works at detection limits required for the protection of foods from intentional and

unintentional contamination with pathogens. Improved testing methods such as these will provide food processors with a way to assess the microbiological safety of products and monitor contamination within the processing environment. It will also facilitate the screening of foods for intentionally added pathogens. With further development, our prototype can be used to help assure the safety of food, decrease testing costs incurred by the food industry, and protect our food supply from acts of bioterrorism.

c. Scope of Impact – National

Key Theme: HACCP

a. Issue: The number of people developing food borne illness has been steadily increasing since the 1970s. Food borne illness resulting from fruits and vegetables is now equal to that occurring from meat sources. Many produce items are not cooked and many consumers do not wash fruits and vegetables. Outbreaks of food borne illness can be costly and are a humanitarian concern for the commodity producers. Prevention of contamination is the first line of defense against food borne illness. FDA has initiated a program of Good Agricultural Practices (GAPs) to help educate farmers and their employees about reducing food borne illness. The project is responsible for providing initial training 20,000 commercial fresh fruit and vegetable handlers allowing them to acquire the knowledge and skills in GAPs in the Southeast. Over 150 County and Area Extension Agents from participating states, whose responsibilities include working with packinghouse operators, will receive additional instruction in HACCP-type design, implementation and verification. The "one-on-one approach" is needed to effectively reach each operator because each retail packing operation has unique characteristics that require special consideration in the development of a FPFS program.

b. Impact: Growers across the state and region are now aware of the importance of a Food Safety Plan for Fresh Produce. A special schools and other meeting about how to comply with a third party audit have resulted in 12 NC growers passing the USDA Food Safety Audit and at least 5 others passing other private company audit. The SE FPFS has increased the awareness of the importance food safety by the in industry in NC and across the region.

c. Scope of Impact – National

Key Theme: Foodborne Pathogen Protection

a. Issue: The risk of foodborne diseases from consuming poultry can be greatly reduced if the Salmonella colonization of poultry can be eliminated by the time the birds go to market for processing. NCSU researchers have designed a nutritional strategy that discourages enteric colonization of Salmonella, even if the birds are raised in a Salmonella contaminated environment. This strategy involves dietary inclusion of mannanoligosaccharide from yeast cell walls. These compounds bind to Salmonella and prevent them from colonizing in the gut of chickens or turkeys. Mannanoligosaccharide (BioMos, Alltech, Inc.) was found to turn salmonella-positive chicks into Salmonella-free broilers by the time they went to market at 6 weeks of age. Another strategy was to feed poultry diets containing non-starch polysaccharides (NSP) from small grains along with NSP-specific enzymes. Turkeys fed wheat- or triticale-based diets supplemented with NSP enzymes turned Salmonella-negative by 16 weeks of age (well before market age), whereas a significant number of birds consuming a typical corn-based diet remained Salmonella-positive through to market age. This research clearly demonstrates that Salmonella

colonization can be discouraged without the use of antibiotics and could be a cost-effective way to reduce the risk of contracting a foodborne disease from consuming poultry.

b. Impact: This research documents alternative strategies to antibiotic treatment to control Salmonella in broiler chicks. Salmonella prevention in broiler chicks will lead to a reduction in Salmonellosis.

c. Scope of Impact – National

Key Theme: Foodborne Pathogen Protection

a. Issue: Egg shells, have historically been considered a waste product and environmental concern of the egg processing industry, yet egg shell membranes may one day be used to improve the safety and quality of foods.

b. Impact: Researchers at North Carolina State University have identified three egg shell membrane-bound proteins (β-N-acetylglucosaminidase, lysozyme and ovotransferrin) that work in concert to alter the normal functioning of bacterial cell membranes of several foodborne disease causing organisms (*Salmonella, Staphylococcus, Listeria, E. coli*) resulting in a significant increase in their sensitivity to heat treatments. Their future use in food processing systems may mean that heat sensitive foods could be processed at lower processing temperatures and for shorter times resulting in reduced process costs, less nutrient loss, and improved product safety, quality and functionality.

c. Scope of Impact – National

Key Theme: Food Quality

a. Issue: Probiotics are microbial cultures that are considered to provide a variety of health benefits, including stimulation of the immune system, maintaining the proper microbial balance in the gastrointestinal tract, limiting antibiotic associated diarrhea, cancer retardation, antagonism to enteric pathogens, and reduction of intolerance symptoms to lactose. The predominant group of microorganisms considered to elicit these probiotic properties are members of the lactic acid bacteria, most notably species of Lactobacillus and Bifidobacterium. NCSU researchers and other in collaboration with a sequencing laboratory at the California Polytechnic State University, completed the genomic sequence of Lactobacillus acidophilus NCFM, the probiotic culture used widely in yogurts and Sweet Acidophilus Milk. The project is continuing efforts to identify genes in *L. acidophilus* that are important to probiotic functions and determining whether or not expression of these genes are affected when the bacterium is exposed to dairy components, products, and environments.

b. Impact: One region responsible for the Lactobacillus acidophilus NCFM's ability to metabolize complex carbohydrates was characterized in depth. Complex carbohydrates are naturally found in breast milk and are known to selectively stimulate the growth of beneficial organisms, such as lactobacilli and bifidobacteria in the gastrointestinal tract. Genomic efforts directed toward many members of the lactic acid bacteria are now revealing the mechanisms through which these organisms preserve our food, colonize our gastrointestinal tract, and evoke important benefits to the general health and well being of 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 that 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 in which we live. 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 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.

Performance goal 1, which seeks adoption of human health and hazard reduction strategies centering on food choices, habits and consumption.

1) Quantifiable and applicable ways to document and compare sensory perception of flavor and to further define the role that specific chemical components of food have on sensory perception of flavor are being developed.

- A protocol for continuous flow microwave processing of sweet potato puree was developed. Several food processing companies have conducted test runs on the microwave unit in our pilot plant, and the results of the runs have interested several of them in pursuing this technology. A patent application was filed based on the results.

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

- A study involving Mutating genes for enzymes of the Campylobacter jejuni indicates the characterization of the energy metabolism pathways and enzymes of C. jejuni is an important first step in developing specific inhibitors of this food-borne pathogen.
- Studies of the human metabolism of deployment-related chemicals will enable the U.S. Army to conduct better risk analysis of chemicals used by our troops.
- A study demonstrated that low concentrations of certain pesticides are capable of dramatically altering in vitro hormone metabolism in humans, providing an alternative explanation for endocrine disrupting effects of pesticides.
- Several methods have been used to make genome-wide historical inferences of mutation, recombination and inbreeding in the genome of *P. falciparum*, the causative agent of malaria. These can be used help identify genomic regions that allow *P. falciparum* to adapt to new environments and will facilitate the development of strategies to control it, as well as our understanding of the degree to which humans have influenced the global spread of *P. falciparum*.
- In response to the issue of whether some environmental chemicals may be eliciting toxicity to humans and wildlife by interfering with normal endocrine function, a research and training program aimed at the following is operational:
  1) Documenting incidents of environmental endocrine disruption.
  2) Elucidating mechanisms by which chemicals elicit endocrine-disrupting toxicity.
  3) Developing tools to monitor for the presence of endocrine-disrupting toxicity in the environment.
  4) Evaluating the consequences of endocrine disruption to both humans and nonhuman species.
  5) Develop means for assessing toxicity of chemical mixtures, as they occur in the environment.
- 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 steppingstone to mapping genes affecting age-related human diseases such as Alzheimer's and Parkinson's diseases.
- Probiotics are microbial cultures that are considered to provide a variety of health benefits, including stimulation of the immune system, maintaining the proper microbial balance in the gastrointestinal tract, limiting antibiotic associated diarrhea, cancer retardation, antagonism to enteric pathogens, and reduction of intolerance symptoms to lactose. Genomic efforts directed toward many members of the lactic acid bacteria are now revealing the mechanisms through which these organisms preserve our food, colonize our gastrointestinal tract, and evoke important benefits to the general health and well-being of humans.
- Our analysis of RNase P RNA structure and variation has resulted in the widespread use of this gene as a phylogenetic tracer for the identification of bacteria, including the pathogens *Chlamydia* and *Bartonella*.

- 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.

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:

- A new pest management program based on low-risk insecticides, insect growth regulators, and biological control agents was developed. This program has reduced by 90% both insecticide use and labor costs associated with pest control.
- The pest control industry continues to depend on calendar-based, broadcast applications of broad-spectrum, neurotoxic insecticides in food-service and residential structures, including homes, nursing homes, restaurants, and public schools. Researchers discovered, isolated, identified and synthesized the sex pheromone of the German cockroach, the most important household pest. This attractant, in combination with other pheromones and food attractants, can now be used in traps, baits and insecticide formulations to control cockroach populations.
- The production of mutations in Alphavirus membrane proteins has lead to the development of a new (recently patented) technique for production of vaccines against arthropod-borne viruses. There are more than 700 of these viruses known, producing 100 million cases of human disease per year, while 2.5 billion people are at risk of contracting one of these diseases annually.
- 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
$181,908	$1,960, 639	$835, 210	$682,983	10.07	30.39	18.20	3.26

Key Theme: Human Nutrition

a. Issue: Proteins and polysaccharides (complex carbohydrates) provide foods with structure and nutrition. Whey proteins from milk have high nutritional value, but lack in some chemical and physical properties to function in certain food applications. The goal of our research program is to provide the fundamental scientific understanding of factors determining the texture, appearance and stability of foods, and how whey protein ingredients can be modified to achieve desired functions.

b. Impact: There is a worldwide market in whey-based ingredients. Those high in protein are called whey protein concentrates (which contain 35-80% protein) or whey protein isolates (which contain > 90% protein). In 2004 there was 264.2 million pounds of whey protein concentrate produced. At North Carolina State University, we have determined the mechanisms responsible for the functionality of whey proteins in many foods. For example, we have shown that whey proteins can be heat-processed into polymers that have unique functional properties, and that these polymers can be added to process cheese for texture improvement without loss of melting quality. This technology has produced three patents, which have been licensed for development. Recent research has shown how whey proteins can be used in a variety of nutritional beverages.

c. Scope of Impact – National, International

Key Theme: Human Nutrition

a. Issue: Foods and food ingredients are widely used in a variety of applications. Consistent sensory quality is required to optimize existing markets and to expand into new market segments. Flavor problems (off-flavors or inadequate product understanding or market positioning) cause the food industry billions of dollars every year. Consistent quantifiable ways to document and compare flavor in the industry are lacking. Further, an understanding of the relationship between chemical components and their impact on sensory perception of flavor is lacking. The goal of this research is to provide quantifiable and applicable ways to document and compare sensory perception of flavor and to further define the role that specific chemical components of food have on sensory perception of flavor.

b. Impact: Standardized sensory languages have been developed in the laboratory for application with cheese, butter, fluid milk, and dry milk/whey dairy ingredients. Instrumental and sensory techniques to link specific chemical compounds with flavor have been developed. Relationships between analytical measurements and consumer quality perception have been established. Fundamental and usable technologies are provided through the development of quantifiable and validated sensory languages for dairy products. The role that specific chemicals(s) play on sensory perception of specific flavors lays the groundwork for an understanding of how to control, maximize, or prevent formation of specific flavors and/or flavor profiles in foods which helps to maximize quality and market demand. Effective marketing strategies can also be developed. The value of these tools and findings to the dairy industry has been estimated at more than one million dollars per year.

c. Scope of Impact – National, International

Key Theme: Human Nutrition

a. Issue: Considerable quantities of edible meat from trimmings and deboned carcasses of meat, poultry and fishes continues to be wasted, and many smaller pelagic fish species are hardly utilized

for food, being converted primarily to fish meal for animal feed. Food Science researchers, working in conjunction with colleagues at the University of Massachusetts and the University of Florida, have developed two important processes to address this challenge. Firstly, a new method of recovering and refining such meats, which removes fat, connective tissues (including skin) and bone, was developed and is being commercially implemented into the seafood industry this year (with interest from meat and poultry once labeling has been approved by USDA). Secondly, a method of solubilizing and injecting this meat protein into intact fillets and cuts of meats, poultry and seafoods was developed.

b. Impact: In tandem these technologies enhance the texture and taste (succulence) of meat, poultry and fish products while reducing the cost to consumers. Considerable value can be added to both the recovered meat and the treated meat cuts as a result. Because profit margins in the muscle foods industries are relatively small, this additional boost in value will provide tremendous returns to the industry while keeping the cost of muscle foods lower for consumers, world-wide. The new meat recovery method also reduces treatable effluent from meat, poultry and seafood processing factories.

c. Scope of Impact – National

Key Theme: Human Health

a. Issue: Obesity is a major health issue in the USA. Obesity is a complex trait affected by many genes. Safe and effective drugs that can reduce body fat is a major interest in biomedical research. However, just as important is knowledge on how a specific drug effects genes in lipid metabolism.

b. Impact: We have used a mouse model developed in my laboratory that is moderately obese and has typical symptoms associated with obesity, eg., high glucose and cholesterol levels in blood. We have shown that the expression of specific genes involved in lipid metabolism are either up or down regulated when these mice are fed CLA an anti-lipogenic agent. These studies provide a valuable approach to sorting out the mechanisms by which a specific anti-lipogenic agent functions in an obese mammal.

c. Scope of Impact – National, International

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. Researchers 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. This research has successfully screened three compounds, and tests are being completed on an additional two.

b. Impact: Work with ovarian cancer has enormous potential both in terms of saving research dollars and in saving human lives. Screening these compounds in women would cost approximately $50 million per compound. In the first study, only one of the three compounds screened appeared effective. The two that were found not effective in birds at a cost of $300,000 would have cost $100 million and 5-7 years had they been screened in women. The time factor alone with women's lives at stake is a major impact.

c. Scope of Impact –National

Key Theme: Human Health

a. Issue: Arsenic and other heavy metals have been detected in playgrounds across the US. The source has been determined to be the mulch used to cover these playgrounds. Consumers are concerned for the safety and welfare of their children. There were no national standards for these products in 2004.

b. Impact: Scientists at North Carolina State University have cooperated with industry researchers and the Mulch and Soils Council to develop standards for mulches, including a test for arsenic, as well as methods and techniques for measuring these standards. It has been determined that the arsenic found in playgrounds came from mulches composed of recycled pressure-treated wood products containing chromated copper arsenate (CCA). As a result, CCA materials have been banned by the Mulch and Soil Council for certified mulch products. The Mulch and Soil Council has adopted a nationwide program to certify that mulch is free from CCA contamination. The Home Depot, the largest seller of mulch products in the US, had all mulch products sold in their stores in 2005 certified under this program. Other national retailers, such as Lowe's are encouraging all of their vendors to certify their products.

c. Scope of Impact –National

Key Theme: Human Health

a. Issue: *Campylobacter jejuni* has emerged as the most prevalent bacterial food-borne pathogen in the world. There are an estimated 2.5 million cases of campylobacteriosis in the U.S. annually, with a cost of infection between 1.2 and 1.4 billion dollars.

b. Impact: We have mutated many of the genes for enzymes of the *Campylobacter jejuni* respiratory chain. We have shown that the lack of many of these enzymes significantly impairs the ability of *C. jejuni* to grow in the conditions that exist in the chicken intestinal tract. Reduction in the level of *C. jejuni* contamination of food supply is a priority in the fight to reduce the personal and economic burden of campylobacteriosis. Enzymes of central metabolism are a logical choice for rational drug design, as they are required for an organism to remain viable. Characterization of the energy metabolism pathways and enzymes of *C. jejuni* is an important first step in developing specific inhibitors of this food-borne pathogen. Specific inhibitors of *C. jejuni* could safely be used in food animals, unlike medically important antibiotics, the use of which is currently being severely curtailed in non-human animals.

c. Scope of Impact - National

Key Theme: Human Health

a. Issue: Despite advances in medicines and vaccines, many diseases continue to plague human and animal populations. Cancer, heart disease, and diabetes, to name just a few, are still rampant in the human population and animal populations face a variety of new infectious agents. In the past,

research into the microbes that cause disease and the mechanisms used by the immune system to fight disease, has yielded great dividends. It is likely, therefore, that continued research in these areas will yield cures for many of the disorders that affect human and animal populations.

b. Impact: Research in my laboratory focusing on auto-immune disease and immune pathology has identified key molecules whose activity is necessary for the tissue damage normally associated with these diseases. We have also identified a derivative of a botanical compound which may suppress the development of auto-immune disease.
The molecules we have identified as critical for development of autoimmune disease could be used as targets for pharmaceutical development. The botanical we have identified may itself be useful for the treatment of a number of disorders including Alzheimer's disease.

c. Scope of Impact - National

Key Theme: Human Health

a. Issue: Genomic information is being gathered at an enormous rate. But we are still in the dark as to the mechanistic details of how genomic information is decoded accurately by RNA during its translation into protein. Without knowledge of the structural mechanisms involved in protein synthesis, we will lack important fundamental information about translation, and ways in which we can apply it.

b. Impact: RNA chemistries and structures critical to accurate decoding of genomic information into proteins have been revealed through sophisticated biochemistry and biophyics techniques including nuclear magnetic resonance and x-ray crystallography.
The discoveries have the potential of being applied to biomedical research for targets of intervention in pathogenesis. They also open the possibilities of manipulating protein synthesis through introduction of new amino acids.

c. Scope of Impact - National

Key Theme: Human Health

Issue: The agricultural economy of North Carolina has suffered major losses as traditional tobacco markets have declined. New enterprises are badly needed to augment declining revenues from traditional crops. One approach is to apply biotechnology to develop new value-added products that can be produced in traditional crops to provide new market opportunities for growers without the need for re-training or extensive new capitalization. We are focusing our efforts on development of technologies with which transgenic tobacco can be used to produce vaccines against papillomaviruses. Human papillomavirus 16 (HPV-16) is the primary cause of cervical cancer. Currently, our group is employing canine oral papillomavirus (COPV) as an animal model for production of these vaccines, because the efficacy of COPV vaccines produced in other systems has been extensively proven, and because it is possible to test the efficacy of a plant-derived vaccine against COPV in a dog model. This protein can be isolated and purified post-harvest. During this reporting period we have demonstrated that VCP5, a plant optimized gene encoding COPV L1 functions properly in transgenic tobacco and results in the accumulation of L1 protein.

We are also working to extract economically important secondary compounds for which significant markets currently exist. Finally, we are working to develop methods for the production of high value proteins in transgenic tobaccos grown in a modified float-bed system in contained greenhouses. Further, we are developing methods by which to extract specific proteins from the green biomass.

Impact: At this time, tobacco production in the U.S. is undergoing radical changes. New uses for tobacco can be introduced. A vaccine for COPV is an excellent candidate for a value-added product. There is a significant market demand for the vaccine. Further, the technologies we are developing for production of these products in contained greenhouse facilities, and the methods we are developing for their extraction can be applied to a very wide variety of other products.

c. Scope of Impact - State, National and International

Key Theme: Human Health

a. Issue: Arthropod bourne viruses are major sources of human disease. They are collectively second only to malaria as world health problem number one. About 700 of these agents are presently known with emerging strains appearing annually. For one of these agents, Dengue Fever, approximately 100 million cases are reported annually with many more cases unreported. About 2.5 billion people are at risk of contracting this disease annually. Despite the enourmous economic and medical impact of these agents very few effective vaccines exist for their control. Live virus vaccines, which are the most effective forms of vaccines, have been particularly difficult to produce.

b. Impact: We have developed a technique for the production of live virus vaccines for arthropod vectored viruses. This technology is based on the discovery that evolution has provided these viruses withy genetic information essential for replication in one of the two hosts (mammals and insects) but not the other. We have identified genetic elements required for efficient replication in the mammalian host and removed them. These deletion mutations restrict the growth of the virus to the insect host resulting in a host range mutation that is a deletion with little prospect of reversion to wild type. Injection of the insect produced virus into mammals results in the production of high titers of neutralizing antibody and protection against challenge with wild type virus in the absence of disease. In principle this technology will produce a live virus vaccine against any of these arthropod vectored diseases for which a cDNA clone can be produced. The significance of this possibility is obvious. The research conducted in this laboratory has led to a new technology for the control of human and animal disease.

c. Scope of Impact - National

National Goal 4: GREATER HARMONY BETWEEN AGRICULTURE AND THE ENVIRONMENT

Overview

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. Agricultural

producers, agribusiness professionals, public officials, agency personnel, special interest groups, university research and outreach personnel, and the general public are all concerned about environmental quality in North Carolina. Mandates from state government to reduce odor and eliminate the use of lagoon/sprayfield waste treatment systems in confined animal operations are having a significant impact on the direction and urgency of research and outreach efforts in the environmental area.

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.

1) North Carolina State University, with support from the North Carolina Ecological Enhancement Program, has evaluated techniques for restoring and creating wetlands at several sites. Research and monitoring indicate that within a few years restored wetlands provide many of the functions and values of natural wetlands. The goal of the research in progress is to measure and document establishment and growth of marsh vegetation in restored riparian zones and to determine the role of the vegetation in improving water quality by removal and accumulation of sediments, nitrogen, and phosphorus.
2) The Geospatial and Precision Technologies Regional Education Initiative has developed customized soil surveys designed to improve management decisions in production agriculture systems. The soil surveys are available on the Internet at http://www.openag.info in a variety of formats, including ESRI shape file format and ESRI Personal Geodatabase format.
3) Scientists at North Carolina State University have developed and utilized a variety of techniques to assess soil, hydrologic, and site parameters that affect wetland restoration success. The methods being used include conventional techniques traditionally used to assess soil characteristics, hydrology, and vegetation. In addition, several relatively new remote sensing technologies are being evaluated for their potential to evaluate factors affecting restoration success and to monitor restoration progress. One of these technologies, ground penetrating radar, has proven useful in delineating and estimating the depth to clayey subsurface soil horizons that are likely to serve as aquitards to foster restoration success.
4) Scientists at North Carolina State University have been studying agricultural production fields in various parts of the state to characterize soil spatial variability and its impacts on crop production. They are developing improved strategies for soil sampling, and for determining and applying site-specific variable rates of fertilizer and lime. Electronic instruments capable of measuring soil electrical conductivity rapidly are being tested to determine if soil electrical conductivity can be a useful parameter to guide soil management for crop production.
5) 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 system failure thus the overestimated of its depth results in systems being installed too deep in the soil and subject to premature failure.

6) A multidisciplinary team was assembled to develop a methodology for conducting a business feasibility analysis for marketing value-added products derived from alternative swine manure treatment systems and to identify potential value-added products and information for characteristics of these value-added products to determine the ones with the highest profitability potential. The project used an example product to demonstrate the implementation of target costing and value engineering processes.
7) Several studies have been completed to determine the effects of removing fiber fractions from corn through processing (dehulled, degermed corn) on pig performance and excretion of nutrients to the environment. Effects on performance of nursery pigs, growing-finishing pigs and sows were minimal when fiber was reduced, and improvements in feed efficiency were observed. Nutrient excretion was drastically reduced in pigs fed processed corn products. The effects of fiber type and level on ammonia and odor emission are currently being evaluated and it is anticipated the odor signature from swine facilities will be significantly affected.
8) We now know that one modification of typical sediment basins will increase sediment removal from 60-70% to more than 90%. We also have found that very small amounts of a very safe organic chemical can cut turbidity by more than 90%, resulting in relatively clear water.
9) Locating and installing septic systems shallower in the soil based on revised soil criteria may save the cost of repairing or replacing a failing system. Currently, approximately $70 million (30% of the total estimated $250 million 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 several million dollars as well as alleviate an environmental and public health risk.
10) Because land application of animal waste is a management practice in swine production, transfer of resistance to indigenous microorganisms could produce a significant reservoir facilitating the spread of resistance across ecosystems. If the bacteria in waste material readily transfer antibiotic resistance to environmental bacteria, our results may shed some light on the fate and transport of antibiotic resistance genes to our ground and surface waters.
11) Successful wetland restoration is an environmentally sound method of increasing natural habitat and removing and transforming pollutants from water flowing from nonpoint sources. Returning prior converted farmland that is located adjacent to sensitive estuarine waters to wetlands is expected to improve water quality and allow shellfish beds to be opened for harvesting and remain productive.
12) Pollutants entering the soil above a water table may move laterally within the capillary fringe before entering the water table. If the findings hold true for different types of soils and geologic materials, assessing lateral movement of pollutants from waste disposal facilities and other areas of interest must include sampling the capillary fringe in addition to different depth intervals below the water table.

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

$503,711	**$3,225,053**	**$1,011,354**	**$1,079,569**	**12.86**	**16.04**	**22.84**	**3.34**

Key Theme: Water Quality

a. Activity: 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 BMP's where NCSU 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. Currently there is almost $300,000,000 funding available for the installation of riparian buffers to improve water quality in NC.

c. Scope of Impact - State Specific

Key Theme: Air Quality

a. Activity: CALPUFF and ISCST3 Gaussian dispersion models were evaluated for odor modeling in predicting downwind concentrations and back-calculating area source odor emission rates. The comparison between predicted downwind concentrations and field-sampled downwind concentration measurements indicated that CALPUFF could fairly well predict average odor downwind concentrations. However, ISCST3 tended to predict lower concentrations than were measured. Both CALPUFF and ISCST3 models failed to predict peak odor concentrations using constant average emission rate. Odor emission rates obtained by back-calculating fluxes using CALPUFF and ISC models with the same field measurements of downwind odor concentrations are significantly different. It indicates that back-calculated emission rates from different dispersion models are not comparable.

b. Impact: Odor dispersion techniques have been used to determine setback distances from neighbors and to quantify odor emission values. The research results from this study bring a novel discovery that back-calculated emission rates from different dispersion models are not comparable. This finding has a significant impact on development of odor modeling techniques.

c. Scope of Impact - State Specific

Key Theme: Water Quality/Soil Quality

a. Issue: NC State scientists have developed techniques using aerial color-infrared photography to determine the optimum timing and rates of N fertilization for winter wheat and corn. These techniques are used to determine where in the field nitrogen fertilizer is needed and in what quantity.

The remote sensing-based technique recommended a more profitable N fertilizer rate than the current recommendations based on "Realistic Yield Expectations." In some cases, this was accompanied by less surplus N to contaminate ground and surface waters, and lower nitrate concentrations in shallow groundwater. Scientists are assessing other remote sensing techniques to characterize the spatial variability of soil characteristics that affect crop production and N-use efficiency. Another product of this project has been a detailed statistical modeling sequence for the analysis of spatially correlated data that is common in site-specific, variable rate ("Precision") agricultural research.

b. Impact: Using aerial color infrared photography of corn and wheat fields to determine where N fertilizer is needed and in what quantity can help optimize N-use efficiency and improve N fertilizer profitability for producers. Optimizing N fertilization sometimes, but not always, minimized the amount of excess N that can pollute ground and surface waters. The statistical methods developed will have widespread application to the analysis of precision agricultural research worldwide.

c. Scope of Impact - State Specific

Key Theme : Integrated Pest Management

a. Activity: Researchers at North Carolina State University have cooperated with colleagues at six other Land Grant Universities in the eastern US on a project to develop and implement reduced-risk pest management programs for eastern tree-fruit growers. By relying on the use of new reduced-risk insecticides and mating disruption, this project has demonstrated that apple insect pests can be adequately controlled with using reduced-risk strategies. The higher cost of this new technology represents a 2% increase in production costs to growers. Additional research is underway to reduce the cost of these programs.

b. Impact: This research has provided the North Carolina apple industry with an economically viable alternative to managing insect pests that poses considerably less risk to the environment, farm workers, and public health, compared to organophosphate insecticides.

c. Scope of Impact - State Specific, Multistate Research

Key Theme : Water Quality/Soil Quality

a. Activity: In order to reduce phosphorus and pathogen losses from land application of animal wastes and reduce negative impacts on surface water quality, several approaches are being taken, as more than one solution is required (i) reduce the phosphorus concentration and solubility in poultry waste in cooperation with poultry scientists, (ii) treat animal wastes with lime to kill pathogens and stabilize phosphorus and (ii) improve animal waste management using the Phosphorus Loss Assessment Tool to decrease potential for P losses from manure-amended soils.

b. Impact: Studies have shown that the phosphorus concentration and solubility in poultry waste can be decreased by dietary modification. Lime treatment of broiler litter and layer manure can reduce pathogen counts and stabilize phosphorus, reducing environmental risks associated with land application of wastes. Further studies are being conducted to identify the most economically beneficial rates and methods for implementation of these novel technologies. For improved management of animal waste the phosphorus loss assessment tool (PLAT) for NC was developed by

a technical committee and the first version was released recently. This valuable tool identifies fields with a high risk of phosphorus loss and helps farmers decide where manure applications can proceed without risking excessive phosphorus losses. Extension presentations will be conducted to assist implementation of PLAT and further studies are planned to validate and refine PLAT.

c. Scope of Impact - State Specific

Key Theme: Riparian Management

a. Activity: A fundamental question relating to stream restoration is how to determine the appropriate dimensions, patterns, and profiles of constructed stable channels so that they will remain naturally stable. The only way to confidently answer this question is to develop a database of physical measurements from "reference" stream reaches, which are currently naturally stable. The information on shape, size, and material measured from reference reaches can be used to design restoration projects that meet hydrologic and biological standards. NC State University faculty and students initiated a comprehensive research and education program over the past decade to develop the necessary knowledge and teach users how to effectively apply it. NC State University faculty have provided leadership for conferences and workshops throughout the Southeastern USA attended by over 4000 natural resource professionals, in addition to 50 grant-funded projects across the state to demonstrate and evaluate stream restoration concepts. Projects range from very small streams in residential communities to large rivers in agricultural watersheds. Many different agencies and organizations participate in these projects by providing funding, personnel, volunteer labor, and educational support.

b. Impact: The level of understanding among professional hydrologists, engineers, biologists, and natural resource managers about stream restoration principles and applications has increased dramatically over the past four years. Many regulatory and funding agencies are coming together to develop design criteria based on the applied research conducted by NC State University faculty and students. Many landowners and contractors are seeking the expertise at NC State University for recommendations on how to successfully restore impaired stream channels.

c. Scope of Impact - State Specific

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

Overview:

The transformation in rural communities and rural life that began after WWII and continues today has resulted in a special set of opportunities and challenges, the solutions of which depend partly on timely and effective research on the part of the Land Grant system, in general, and the Colleges of Agriculture and Life Sciences, in particular. Social and economic restructuring, the reorganization of agriculture and natural resource-based industries, de-industrialization and outsourcing, the communications revolution, the shift to a service-oriented economy, and major demographic changes in population composition and processes are among the major manifestations of the fundamental switch from a mostly rural to a mostly urban society.

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 other 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 improve the atmosphere in which North Carolinians in rural areas live and work. Others have contributed to the development of strategies for improving the economic viability of rural communities. Still others have contributed to the improved health and well being of those living in rural areas.

Research undertaken this year has contributed to the general improvement in the quality of life for Americans, particularly those in the rural South.

The following projects involve improving the life of North Carolinians by improving the quality of the air and water around them.

1) Measuring Quantities of Sediment and Nutrients Leaving Agricultural and Forested Land – A scientific dataset that quantifies these impacts has been built and used to measure the impact of controlled drainage and riparian buffers. This has led to development of scientifically based, best management practices to reduce non-point pollution coming from agriculture.
2) Improved Water Quality Using Aerial Color-infrared Photography – Remote sensing-based techniques were used to determine the optimal timing and rates of N fertilization for winter wheat and corn. This has resulted in less contamination to ground and surface waters.
3) Dietary Modification of Poultry Waste – Lime treatment of broiler litter and layer manure has been shown to reduce pathogen counts and to stabilize phosphorus, reducing environmental risk from these pollutants.
4) Controlling Ammonia Emissions from Swine Waste – Efficiency of Nitrogen and ammonia removal from swine waste has improved from 70% to over 90% with a new intermittent aeration technology.
5) Recycling of Food Scraps, Yard Wastes, and Other Organics – Vermicomposting techniques are being used to provide a soil amendment that increases nutrients and enhances soil structure and drainage. A reduction in waste disposal costs, less expensive soil amendment product costs and conserved landfill space has resulted from this work. This benefits to North Carolina's growing nursery industry.

Improved safety of food products was addressed by the following projects.

1) Finding Alternatives to Methyl Bromide for Strawberry Fumigation – Methyl Bromide is a pesticide that is scheduled to be banned by EPA in production of many fruits and vegetables. Researchers have found safer chemical and cultural methods that also provide increased net returns to strawberry growers in North Carolina.
2) Testing for Aflatoxin in Peanuts – A method has been developed at NC State to predict the performance of aflatoxin sampling plans which provides a more effective aflatoxin control program for the detection and removal of aflatoxin-contaminated almonds and reduce the risk to consumers from eating aflatoxin-infected nuts.
3) Testing for Multiple Food Borne Pathogens with a Single Test – Researchers at NC State have developed a testing method to detect multiple food borne pathogens that works at detection limits required for protection of foods from intentional and unintentional contamination with pathogens. This will facilitate the screening of foods for security purposes as well as for general food safety purposes.

The following project involved improving the quality of life for North Carolinians via improved recreational opportunities.

1) Improving Habitat for Anadromous Fishes – NC State researchers found that removal of dams that are no longer needed will increase spawning populations of American shad and striped bass in the upper reaches of North Carolina's rivers. This will improve angling opportunities in the state and help the tourism industry.

Youth and adult health and well-being were addressed by the following projects.

1) Identifying Potential Child Abusers – A set of questions was developed by researchers at NC State that was able to detect child abusers with near 100 percent precision. The Child Abuse Potential Inventory is now being used in every US state and in many countries around the world. Its highly predictive capacity has made it a major tool in preventing potential child abusers from being employed where they have contact with children and for diagnosis and therapy of child abusers.
2) Identifying Social and Spatial Structure of Termite Colonies – Researchers at NC State have found that many homes may have up to three termite colonies actively infesting a house simultaneously, may have numerous colonies within 50 ft. of the foundation, and may have up to 100 colonies per acre in the yard. These studies show that termite treatments limited to a small area of a structure may not effectively protect it against attack by subterranean termites. This will result in more effective treatment of residences for termites and preserve the integrity of North Carolina housing.

Racial and gender issues in the rural South were addressed by the following projects.

- Gender and Race Discrimination - Damage estimates were prepared for the Abercrombie and Fitch race and sex discrimination law suits. The case was settled for 54 million dollars.
- The Consortium for the Black Belt South - A consortium for research and outreach began to address the impoverishment in the Black Belt counties of North Carolina and other southern states. Currently, the consortium consists of NC State University and NCA&T State University. This builds upon research done on Black Belt issues at these and other southern land-grant universities.
- Regional Rural Development for the Black Belt South - Using recommendations from research on the rural Black Belt South, a Bill introduced last year was considered in the U.S. Senate and two Bills introduced in the House of Representatives last year were also considered in order to establish a regional commission for the Black Belt South. These follow a 1993 Bill that was developed from Black Belt research that showed a crescent of over 600 counties in 11 Old South States still had the nation's largest and worst expanse of rural impoverishment.

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
$89,377	$1,523,087	$374,435	$15,159	111.60	7.28	14.48	1.48

Key Theme: Supplemental Income Strategies

a. Issue: The concept of industrial crop "pharming" is growing. The use of renewable resources to produce bulk chemicals (cellulose, starch, sugars), fine biochemicals (peptides, proteins, natural products), and pharmaceutical (vaccines, small molecule drugs, and the ability to genetically engineer both primary and secondary metabolic products to produce an ever-widening array of compounds is an attractive alternative to the current, largely oil-based, chemical company. A concern over the use of food crops as vehicles for "pharming" has led to renewed interest in tobacco as a bioprocess crop. Tobacco could prove to be an excellent base for crop pharming. Much is known about its chemistry and biochemistry as well as its biotechnical manipulation. Green tobacco also inherently produces a number of valuable products including Fraction 1 protein, Fraction 2 protein, cis-abienol, sclareol, Co-Enzyme Q, starch, and residual biomass.

b. Impact: Research at NC State has led to processes for the recovery of native fraction 1 and 2 proteins, and a method has been developed for surface extraction of leaf surface natural products from green tobacco. Work at NC State has also developed technologies with which transgenic tobacco can be used to produce vaccines against papillomaviruses, one of which is a cause of cervical cancer. This work could transform the NC economy. Tobacco bio-processing holds promise to provide new niche crop opportunities to farmers as well as rural industrial development in the form of the processing plants that would, of necessity, be located nearby to the farm operations, thus creating a whole new class of rural employment.

c. Scope of Impact: Regional.

Key Theme: Jobs and Unemployment

a. Issue: To remain viable, our coastal seafood industry must seek value-added propositions that will meet the demand by restaurants and regional specialty markets. Unlike multinational companies that must appeal to a broad consumer base, North Carolina seafood processors are better positioned to exploit niche markets. Surveys show that consumers prefer locally harvested and processed seafood – and are willing to pay a price premium for novel, healthy products and convenience. At the same time, our rural areas are suffering from systemic unemployment.

b. Impact: Several coastal and other seafood processors are beginning to evolve from commodity-oriented to consumer-driven business as they expand into value-added seafood. The North Carolina Seafood Laboratory has helped one western North Carolina processor launch a ready-to-eat (RTE) product to the retail trade and a Pamlico County company to ready five RTE products for a 2006 market introduction. This new strategy will create new jobs in several areas of North Carolina.

c. Scope of Impact – Statewide.

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.

To enhance our efforts to connect with stakeholders, the new Dean has moved to implement a commodity based workgroup structure in which CALS Research-Teaching-Extension workgroups would be identified that focus on specific commodities or groups of commodities. These work groups would facilitate bi-directional flow of information regarding research needs and priorities and outcomes and impacts of our research efforts. Part of the plan would involve the work groups meeting annually with the commodity groups for the purpose of sharing mutually beneficial information.

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

Evaluation of the Success of Multi and Joint Activities

North Carolina State University faculty was involved in 19 Multi-State Research Projects in the Southern Region, 25 Multi-State Research Projects in other regions, and 8 Southern Extension and Research Activities. These activities were all multi-state, 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. The impacts of these projects are indicated in the respective Goal Reports as well as the in the Integrated reports. Some examples of multi-state, multidisciplinary, integrated activities other than those included above are discussed below.

Southern Region Small Fruit Consortium

This consortium is a multi-state, integrated activity that includes North Carolina State University, Clemson University, the University of Georgia and the University of Tennessee. Virginia Tech joined the consortium in September of 2005 bringing the number of states involved to five. Sixteen research proposals were funded for 2006 for a total of $75,831. In addition, SRSFC funded projects 2006-02; 06, 07, 10 and 12 received half matching funds from the IR-4 performance program which totaled $10,750. Thus overall funding for 2006 was $86,581.

Research Sponsored by the Southern Region Small Fruit Consortium in 2005
(projects are listed by: title; project leader(s); lead state; and amount
funded)

Raspberry Breeding for the Southern Region Fernandez, Ballington,
Pesic-VanEsbroeck, Sosinski NC $5,000

Antifeedants, Repellants, and Organic Controls for Tarnished Plant Bug and Japanese Beetle on Caneberries Pfeiffer VA $ 5,000

Enhancement of Bramble Production in the Southeastern U.S. Through Micropropagation, Virus-Indexing, and Field Evaluation for Trueness-to-Type Pesic-VanEsbroeck, Ballington, Fernandez NC $5,000

The Effect of Increased Nitrogen and Potassium Levels within the Sap of Strawberry Leaf Petioles on Overall Yield and Quality of Strawberry Fruit as Affected by Cultivar Hassell, Poling NC,SC $5,000

Paraphlepsius irroratus: A Potential Vector of Xylella fastidiosa, the Cause of Pierce's Disease of Grapes? Sutton, Abad NC $4,981

Use of Phosphite Materials for Control of Pythium Species in High-Density Blueberry Production Systems Brannen, NeSmith GA $5,000

Mummy Berry Control in Organic Blueberries Scherm GA $4,500

Pomace: Waste or Valuable Resource? Gwinn, Ownley GA $5,000

Eastern Piedmont Wine Grape Cultivar Evaluation Wolf, Pattison VA $5,000

Evaluation of Herbicides for Yellow and Purple Nutsedge (Cyperus esculentus and C. rotundus) and Annual Sedge (Cyperus spp.) Control in Young Blackberry Fields Czarnota GA $2,000

Evaluating Protected Culture for Season Extension of Small Fruits Pattison, Wolf NC $5,000

Detection and Management of Anthracnose in Strawberry Production in the Southeast Louws NC $5,000

Horizontal Wells for Irrigation Supply for Blueberries Hawkins, Krewer NC $5,000

Horticulture and Economic Evaluation of Early Ripening Rabbiteyes for Local Sales and Distant Shipping Krewer, Fonsah GA $5,000

Evaluation of Fruit Cracking and Berry Firmness in Rabbiteye Blueberry Germplasm NeSmith NC $4,500

Dendrometers to Measure Water Status and Schedule Irrigation for Small Fruit Crops Rieger GA $4,850

A county agent in-service training on bramble production in the south was conducted January 8, 2005 at the Southeastern Fruit and Vegetable Conference in Savannah, GA. additionally, an educational session for growers on bramble production was sponsored by the SRSFC at the conference on Friday morning January 7, 2005. A total of 33 agents from the four member states and one from MS attended the training. Five agents from each of the member states received full scholarships from the SRSFC to attend the training.

Web Site Activity Number of hits on the Southern Region Small Fruit Consortium web site(www.smallfruits.org) per day was 3,116 for the period of Jan 1, 2005 to December 31, 2005. This is over a 1,000 increase for the same period in 2004.

A regional production guide was completed during 2005 and posted on the SRSFC web site(http://www.smallfruits.org/SmallFruitsRegGuide/index.htm). This document will be updated annually and was sponsored by Arysta Life Sciences Corporation.

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 provides a portion of the salaries and operating funds involved in implementing and evaluating this program. The program is designed to evaluate the yield, maturity (genetic potential), quality characteristics and consumer acceptance of advanced Virginia-type peanut breeding lines.

Based on seed production figures from the 2004 crop year, approximately 82% of the peanuts grown in the state of North Carolina in 2005 were of six cultivars (NC 7, NC-V 11, NC 12C, Gregory, Perry, and VA-C 92R) that were developed and released by the NCSU peanut breeding project either alone or in cooperation with VPI. The three newest NCSU peanut cultivars in the hands of commercial growers, NC 12C, Gregory, and Perry were released by the breeding project in 1996, 1997, and 2000, respectively. Two new cultivars, Brantley and Phillips, were released in 2005, but they currently are in the hands of seed producers only.

Regional Apple Research and Extension Position

North Carolina State University, Clemson University, the University of Georgia and the University of Tennessee support a regional apple research and extension position that 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.

The objective of this ongoing work is to develop cost-effective technologies for achieving consistent cropping in strongly biennial apple varieties in the southeast. Promising data have emerged from these studies that will be published in 2006. Additional research experiments were initiated to further evaluate the potential for various plant growth regulator treatments to improve fruit finish (russet, scarfskin). The objectives of this ongoing research are to reduce the risks of developing fruit cosmetic defects by identifying causal agents and developing effective protectant strategies. Evaluation of new apple varieties for the southeast is ongoing, in collaboration with the NE183 regional apple project. This project has identified several new fresh market varieties that are suited to environmental conditions in the region, including Ambrosia, Cameo, September Wonder, Suncrisp, Autumn Gold and Honeycrisp.

Controls on Pretension and Release in Soils and Solid Amendments

Research to determine why phosphorus is often mobilized from soils when they are flooded to create a wetland. The research suggested that soils high in aluminum oxide minerals could be converted to wetlands with only minimal release of phosphorus into nearby waterways.
Findings will be useful for developing guidelines for evaluating the suitability a parcel of agricultural land for conversion to a wetland. Based on our research to date, soils that have greater concentrations of chemically-extractable aluminum would be less likely to yield mobile phosphorus that could enter waterways and deteriorate water quality.
Cooperating states: FL,GA,KY,LA,MO,MS,NC,SC,TN,TX,VA

Technologies for the Genetic Improvement of Poultry

The applications of poultry wastes from intensive animal production systems have resulted in more phosphorus being applied than is needed for agronomic purposes and can contribute to eutrophication of lakes and streams. Has identified and engineered an endogenous avian “phytase” gene of the chicken to allow for the efficient utilization of plant phosphorous.
Breeding companies have the potential to develop new lines of poultry with better utilization of phosphorus.
Cooperating states: AR,CA-D,DE,GA,IA,IL,IN,MD,MI,MN,NC,TX,VA,VI

Systems for Controlling Air Pollutant Emissions and Indoor Environments of Poultry, Swine and Dairy Systems

Odors and noxious gases are known to come from livestock and poultry facilities. The six state cooperative project has as the main objectives the quantification of the amounts of specific gaseous emissions. Facilities and equipment have been installed and operated to measure, quantify, and record gaseous emissions from a broiler house in North Carolina. Considerable data has been collected and is ready for analysis. Quantification of specific gaseous emissions will provide the necessary data to determine what, if any, limitations should be implemented in the form of regulations, and to establish whether cultural changes in the growing of broilers to minimize emissions are warranted.
Cooperating states: MN, TX, IA, IN, IL, NC

Soilborne Plant Pathogens for Sustainable Agriculture

A 5-yr survey was undertaken of floriculture crop production facilities in the state to characterize the species of Phytophthora attacking ornamental crops. Over 40 different crops were sampled at 29 production facilities and 483 isolates of Phytophthora were collected.
The widespread occurrence of Phytophthora diseases in floriculture crops and the development of fungicide resistance in the Phytophthora population have important implications for producers. The results of the survey suggest that growers do not have adequate integrated pest management (IPM) programs in place for their crops and that other fungicide products should be used when mefenoxam-resistant Phytophthora is present. Modification of existing IPM programs also should consider economic thresholds in relation to current cropping practices. USDA Southern Region IPM.

Biological Control of Arthropod Pests and Weeds

Biological control is a tool used in Integrated Pest Management (IPM) programs in both "conventional" and "organic" agriculture that can reduce the use of pesticides and their side effects. North and South Carolina organic farmers have stated in surveys that insect pests are their number one problem. Comparisons of insect populations and damage were made between organic and conventional cropping systems. Evaluations of beneficial organism releases on organic farms were conducted. Studies of commercially available beneficial insect habitat seed mixes have provided growers with much needed guidance on whether to use these products, and if they choose to, how best to plant them. A simple, easy to use method was implemented to dramatically increase the lifespan of parasitic insects released for insect pest management. North and South Carolina.

Genetic Bases for Resistance and Immunity to Avian Diseases

This study was conducted to examine if the relationship between dietary supplementation of selenium to turkey (Meleagris gallopavo) hens and the embryonic expression of hsp70 and GSHpx activity in heat stressed embryos. Results of this study suggest that selenium nutrition and its stimulation of the antioxidant glutathione/glutathione peroxidase and thioredoxin/thioredoxin reductase enzyme systems provides a buffer against the potential damaging effects of free radical production. This research clearly shows that the use of organicselenium can alleviate stress reactions permitting chickens to grow at an advance pace. This alone can have a significant impact on the poultry industry potentially allowing additional farm gate revenues of $40 million per year in North Carolina alone. More importantly, the improved performance and yield can be beneficial to consumers who potentially could purchase poultry products at even less cost.
Cooperating states: AL,AR,CA-D,DE,IA,MD,MS,NC,NH,NYC,SC,TX

Improvement of Thermal and Alternative Processes for Foods

Development of a protocol to process liquid foods on a continuous basis using microwave technology and a protocol for continuous flow microwave processing of sweet-potato puree was developed. Several food processing companies have conducted contract runs on the microwave unit in our pilot plant and the results of the runs have interested some of them in pursuing this technology. A patent application was filed based on the results and a North Carolina company (YAMCO) is pursuing the production of aseptic sweet potato puree using continuous flow microwave technology.
Cooperating states: CA-D,DE,GA,GU,IA,ID,IL,IN,KY,LA,MD,
MI,MN,MO,NC,ND,NE,NJ,NYC,NYG,OH,OR,PA,SD,TN,TX,VA,WA,WI

Animal Manure and Waste Utilization, Treatment and Nuisance Avoidance for a Sustainable Agriculture

Present waste management systems used for swine farms in North Carolina have been under attack by environmental groups and the media. Evaluation of present and alternative swine waste management systems is critical to the continued vitality of the swine production industry and protection of our environmental resources.
North Carolina State University has conducted evaluations of on-farm demonstration projects for innovative swine waste treatment. These projects are joint effort between the "technology provider", swine producer, and NCSU scientists. The N. C. Legislature in 1999 appropriated $750,000 to NCSU and the Animal & Poultry Waste Management Center to conduct the demonstration/evaluation of innovative technologies. Six projects were selected from forty-two proposals that were submitted by the technology providers and reviewed and rated by a diverse panel. NCSU was designated to provide technical and economic evaluation of the technologies. These are in addition to 11 projects previously funded by the Governor's office. Several of those projects have had field days to transfer information to CES agents, swine producers, consultants, and others. An agreement between Smithfield Foods, Inc. and the N.C. Attorney General in July 2000 also designated $15 million to the APWMC for construction and evaluation of several different technologies. Soon after, Premium Standard Farms also gave $2.5 million for technology construction and evaluation. From about 100 proposals, eighteen projects were selected and fifteen have been completed for technology performance evaluation and economic evaluation. The high level of interest in all these projects from various persons within and outside of N. C. has resulted in numerous opportunities for answering inquiries, providing information, hosting visitors, and making presentations. Furthermore, the results have been presented in national symposia and journals to make the information available to the various groups that are highly interested in swine waste treatment and utilization.
Cooperating states: AL, AR,CA-D,CO,FL,GA,GU,HI,IA,ID,IL, IN, KY,LA,MI,MN,NC,OH,PA,SC,TX,VA,WI

Development of Plant Pathogens as Bioherbicides for Weed Control

Nursery crop production is one of the most important agricultural sectors in North Carolina and represents about 13% of US farm revenues. Controlling weeds in container grown nursery crops can be one of the most expensive production cost components. No weed identification guide was available that targeted this important crop production
A full color guide of common and recently introduced weeds of container nursery crops was produced – *Weeds of Container Nurseries in the United States* that has been used as a training resource in nursery weed management workshops in NC, SC, FL and VA.
Cooperating states: CA-D,CA-R,FL,IN,MA,MT,NC,NYC,PR

Engineering for a Bio-based Industry and Economy

Ammonia emission from wastewaters to the atmosphere is one of the major environmental concerns. The main sources for ammonia emission include animal wastewaters, anaerobic digestion liquors, and fertilizer production wastes.
An interdisciplinary research project on ammonia emission control for swine waste management has been conducted. High efficiency of ammonia and nitrogen removal (over 90%) was achieved in a single-sludge reactor. The major pathway of nitrogen removal was found to be ammonia oxidation to nitrite which was then reduced to nitrogen gas. In the projects we have identified mechanisms and the dominant ammonia oxidizing bacteria and nitrite oxidizing bacteria in the intermittent aeration

process for the first time. This will provide a valuable tool for fundamental understanding of the process and future research on intermittent aeration process for nitrogen removal. Cooperating states: AR,AZ,CA-D,FL,HI,IA,IL,IN,KS,KY,LA,MI,MN,MS,MT,NC,ND,NE,OK,OR,SC,SD TN,TX,UT,VA,WA,WI,WVA

Genetic Selection and Crossbreeding to Enhance Reproduction and Survival of Dairy Cattle

As dairy producers continue to face pressures for increasing economic and production efficiency, interests in alternative approaches on farm processing, or possibly converting to organic production have emerged. Current work with pasture-based dairy research at the Center for Environmental Farming Systems is adding additional knowledge to the opportunities for pasture-based dairying in North Carolina including information on use of crossbred dairy cattle in such production systems. More and more producers have sought and received information on use of crossbreeding in dairy cows. It is expected that more than 30% of NC dairy farmers either currently are using some crossbreeding or have some interest in use of crossbreeding in their herds. As part of the project, NC State University began a long-term dairy crossbreeding study in collaboration with Virginia Tech and the University of Kentucky.
Cooperating states: AR,GA,IA,IL,IN,KY,MN,NC,NE,NYC, PA, TN,VA

Development of New Potato Clones for Improved Pest Resistance, Marketability, and Sustainability

The Sweetpotato Breeding Program has a diverse research portfolio. We have active projects focused on developing traditional, specialty-type, and industrial-type sweetpotatoes to meet the near- and long-term needs of the industry. We have also developed and commercialized the Sweet Caroline series of ornamental sweetpotatoes and they are becoming popular in the US and elsewhere. These efforts are focused on developing industrial-type sweetpotatoes for the production of bio-based renewable resources and value-added products. We also continue to work to select and release superior, micropropagated sweetpotato clones to growers.
During 2005 ‘Covington’ a new tablestock variety was approved for release and is Plant Patent Pending. Covington is a high yielding tablestock sweetpotato that is more stable across environments compared to the industry standard ‘Beauregard’. Over 5,000 acres of ‘Covington’ were planted in 2005, representing ca. 15% of the total acreage of sweetpotato planted in NC. Based on NCDA&CS and USDA NASS crop value estimates of $80 million for the 2005 crop, the farm-gate value for ‘Covington’ in 2005 was ca. $12 million. We expect ‘Covington’ will account for ca. half of NC’s sweetpotato crop in 2006. Southeast states.
Cooperating states: FL, ME, NC, NJ, NYC, OH, PA

Host Resistance as the Cornerstone for Managing Plant-Parasitic Nematodes in Sustainable Agriculture

Soybean breeding has produced a remarkably stabilizing effect on the USA soybean industry, raising soybean yields 25% since World War II and providing farmers with protection against an array of potentially devastating diseases. U.S. breeders are faced with the formidable task of creating the new “global genetic edge” in soybean. Transgenic technology while offering many opportunities to protect the crop from disease and enhance market value has not yet identified a ‘yield gene’ or produced a variety which boosts the yield potential of soybean in the absence of stress. Presently the improvement of the yield ceiling in soybean is the domain of the soybean breeder.

This project seeks to enhance the U.S. genetic edge by providing new yield genes to U.S. breeding. The approach is to identify and use:

1) Modern high-yielding Asian soybean varieties
2) Drought tolerant exotic accessions from around the globe as sources of new yield genes for U.S. breeding.

We identified eight promising Asian varieties which likely carry yield genes unique to USA breeding. More than half of U.S. commercial breeders have incorporated these materials into their breeding programs as a result of our findings.
Cooperating states: AL,AR,LA,MN,MS,NC,SC,TN,TX,VA,WA

Regulating Skeletal Muscle Growth and Differentiation

Studies have been initiated to link the mechanisms governing skeletal muscle growth to the diet fed an animal. In collaboration with Dr. Jim Petites' laboratory, we have generated lines of transgenic chicken expressing bacterial β-galactosidase.
The shift in satellite cell sub-populations has been characterized following nutritional manipulations. The transgenic chickens expressing β-galactosidase are an important model for developmental biology research. We have generated and characterized the first lines of transgenic chickens expressing a reporter gene. The transgenic chickens will be employed in further studies aimed at gaining insight into the fate of developing cells in the chicken embryo.
Cooperating states: AZ,HI,IA,ID,IL,IN,KS,MI,MN,MT,NC,NE,OH,OR,SD,UT,WA,WI

Rootstock and Interstem Effects on Pome and Stone Fruit Trees

To increase the profitability and ability of NC tree fruit growers to compete in a global market by increasing fruit quality, achieving consistent annual production, maximizing productivity, reducing inputs and adding value. Diversification of row crop farmers to high-value tree fruit crops as part of a diversified farm operation is an area of considerable interest and potential, especially with growers looking to diversify and stabilize their farm income. In addition, NC growers must diversify their markets to remain competitive and profitable as well as producing value-added products.

Research has been conducted at NCSU over the past four years evaluating strategies and products to control browning for fresh sliced apple industries. In addition, research has been conducted to address major horticultural issues limiting tree fruit production in the southeast. Educational programs have been developed for growers, and potential growers, that provide the latest production information available on horticultural management such as cultivar and rootstock selection, cultural management, economics, post harvest handling and value-added opportunities.

A new commercial business was launched in Henderson County this past January with the ground breaking for construction of a 2.5 million-dollar state-of-the art apple slicing facility. This business will begin operation in May 2006 and will add approximately 20 new employees. This plant will provide apple slices for the retail market, one of the fastest growing fruit markets nationally. The economic benefit to the apple growers, processor and citizens of Henderson County will be significant from the number of new jobs created as well as economic input into the local economy. In addition, the increase in consumption of fresh apples, high in antioxidant anti-cancer properties, will benefit the entire southeast with healthier diet choices in a snack food package.

Educational programs have resulted in many new plantings of peaches across the state. To date

many small operations of peach have been established by full time farmers looking to diversify their operation as well as part-time farmers which were historically non-farmers. Research results have demonstrated the potential profitability of peach plantings with gross sales in excess of $8,000/acre. Cooperating states: AR,CA-D,CO,GA,IA,IL,IN,KY,MA,MD,ME,MI,MN,MO,NC,NJ,NYG,OH,OR PA,SC,TN, UT,VT,WA,WI, ARKANSAS & CA CO-OP-EX'S

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 285 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 72 faculty with research and extension appointments who led integrated projects in 2005. Of those, 62 were supported by Hatch funds along with state, federal and other sources. Hatch expenditures for these projects amounted to: $1,800,252 which was **29.22**% of the 2005 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 #***
Assessing farming system sustainability and research support for organic agriculture production	**6625**
Small fruit diseases and their control	**6747**
Production Strategies For Improved Vegetable Production and Alternative Crops For Diversification	**6596**
Weed management for small fruits and vegetables	**6735**
Weed management in turfgrass and forages	**6704**
Genetic and production environmental influences on processing and planting quality of nutritionally enhanced soybean seed	**6632**
Precision agriculture for agronomic crops and nitrogen management for corn in Eastern NC	**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**
Apple disease management	**6223**
Processes limiting pollen development and release under heat stress in tomatoes and other crop plants	**6623**
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**
Management of Arthropod Pests of Turf and Peanut	**6731**
Ecology and management of European corn borer	**0205**
Weed management and growth regulators for agronomic crops	**6417**
Economic Decision Support For Sustainable Ag Products	**6528**
Plant nutrition programs for mountain crops	**6558**
Cultural Management of Strawberries and Grapes	**6324**
Small fruit production systems	**6681**
Integrated Peach Disease Management	**6160**
Management of arthropods on fruits and vegetables and Western North Carolina	**6402**

Best Management Practices for Anti Gibberellins in Floriculture Production	**6718**
Biological Control of Anthropoids Pests and Weeds	**0303**
Risk aversion, risk shifting and alternative payment mechanisms in settlement of broiler contracts	**6527**
Use of alternative supplements in grazed, hayed and ensiled forage systems for beef cattle	**6736**
Developing Strategies for Improved Pasture Fly Management	**6803**
Nutritional Strategies to Improve the Growth, Productivity, and Profitability of Dairy Cattle	**6605**
Improving reproduction and management of dairy cattle	**6600**
Use of feed additives to reduce aflatoxin transfer to milk.	**6778**
Genetic approaches to enhance efficiency and profitability of pork production	**6792**
Nutritional approaches to enhance swine production efficiency and profitability	**6777**
Maximization of laying hen performance Economic Return, and Egg Quality	**6184**
Fish Food Ingredients Produced By Solubilization/Reprecipitation	**6616**
Strategies to Increase Meat Goat Production	**6701**
Integrating Crops and Livestock Systems	**6602**
Fish Responses to Biotic and Abiotic Factors Affecting Behavior, Growth and Survival	**7257**
Mountain aquaculture research	**6153**
Price Risk Management Strategies in Food and Grains Marketing	**6781**
Economics of adoption of agricultural technologies	**6610**

Assessing farming system sustainability and research support for organic agriculture production

Project 6625

Through extension programming and resource development in organic agriculture, we have enhanced opportunities for extension agents and other state agriculture professionals to work with the growing organic community. Worldwide demand for organic production continues to increase 20 percent per year, and it's important that North Carolina producers are poised to take advantage of the growing market. While there is no mechanism for tracking the number of organic producers in the state or the certified acreage, it is evident that there is increasing interest in a wide variety of organically certified crops and animals.

Small fruit diseases and their control

Project 6747

Blueberry cultivars grown in northern states are neither climate adapted nor disease resistant in the hot, humid South. In an on-going effort, U.S. Department of Agriculture and North Carolina State University plant pathologists worked hand-in-hand with plant breeders to develop disease-resistant blueberry cultivars adapted to low-chill climates. The North Carolina blueberry industry is thriving

due to publicity about the health benefits of blueberry consumption. This would not be possible without the long-term effort to establish disease-resistant cultivars and production methods for the South. In 2005, North Carolina growers harvested a record 26 million pounds with a market value of $36.7 million.

Production strategies for improved vegetable production and alternative crops for diversification
Project 6596
More efficient production of the new variety Covington sweet potato was achieved by determining that optimum in-row spacing is 12 inches. It also appears that more nitrogen is needed to improve production of Covington versus the Beauregard variety. About 80 pounds of nitrogen per season may be needed for Covington rather than 50 to 60 pounds necessary for Beauregard.

Weed management for small fruits and vegetables
Project 6735
Research determined the best timing for control of eastern black nightshade in tomato. Applying control measures from 3 to 6 weeks after tomato transplanting prevented production of eastern black nightshade seeds and prevented yield and quality reductions by this weed, which reduces the development of jumbo tomatoes, the premium grade, more than any other weed.

Weed management and turf grass and forages and plant growth regulators for use in turf
Project 6704
Research is shedding light on why weeds occur where they do in turfgrass systems. Many cultural practices influence weed occurrence. These include irrigation practices as well as design features such as topographic issues. Research shows know that many troublesome sedges occur where water drains on golf courses. Better drainage and design will help reduce weed incidence and thus reduce reliance on herbicides.

Genetic and production environmental influences on processing and planting quality of nutritionally enhanced soybean seed
Project 6632
Phytotron and field studies evaluated the influence of temperature during seed development on subsequent seed quality of high oleic peanut varieties. Educational efforts in the form of meetings, workshops, and publications communicated to seed growers the importance making good management decisions and the consequences of making bad ones. Following our recommendations will result in increased seed quality, will allow seed growers to meet company standards and will allow producers to reduce seed input costs.

Precision agriculture for agronomic crops and nitrogen management for corn in Eastern North Carolina
Project 6425
Research indicated that the use of starter fertilizer treatments featuring N and K resulted in significant improvements in stalk diameter and increases in root mass compared to an untreated check. Yield increases of 22 bu acre^{-1} were found when these treatments were used. An economic analysis indicated growers could increase profit by $12 per acre. From this work extension information was developed describing recommended fertility practices based on soil type and plant population. On-farm visits, field tours, and agent training were done to help identify those growers who would benefit from this management system.

Development and refinement of strategies for peanut production in North Carolina
Project 6466
Studies were conducted to define agrichemical interactions and to continue developing IPM approaches that potentially may lead to more efficient use of crop protection chemicals. Research was also conducted to compare subsurface drip and overhead sprinkler irrigation and to determine if pesticide inputs can be reduced in these systems. Cropping system experiments are in place at five locations in the state, and some of these experiments have included various rotations since 1997. Results from applied research have demonstrated risks associated with adopting reduced tillage systems for peanut. Preliminary research has helped determine the possibility of using hyper-spectral and multi-spectral imagery to improve disease management and to assist in maturity determination. Performance of runner and Spanish market types has been compared in some experiments.

Developing new crops and sustainable production systems for vegetables and medicinal herbs
Project 6595
By the summer of 2005, 40 growers, many of them present or former tobacco farmers were growing medicinal herbs as part of a project to determine whether herbs are a feasible alternative crop in North Carolina. Seven medicinal herb buyers from four states are cooperating on the project, advising on the herbs to be grown, how to handle and test the herbs, and quality issues. Faculty provides farmers with assistance in growing and marketing their crops.

Apple disease management
Project 6223
The incidence and severity of sooty blotch and flyspeck was monitored, and variation in the time for symptom development is being related sprayed orchards in the Pito environmental conditions at the three sites by a master's student at Iowa State. A threshold for eradicant fungicide application of 375 hours of leaf wetting supplied by Skybit corresponded well to a threshold of 225 hours determined by on-site monitors.

Processes limiting pollen development and release under heat stress in tomatoes and other crop plants
Project 6623
Six experiments were conducted to study the effect of potting mixes and their components on seed germination and seedling growth of tomato (*Lycopersicon esculentum* Mill cv. 'Celebrity') and to compare existing commercial organic and conventional substrates with a sample grower mix (peat, perlite, vermicompost, feather meal, kelp meal). Variations on the grower mix ingredients were added in some experiments in order to optimize seed germination and nitrogen nutrition.
Analysis of pH, salts, and ammonium content along with the physical properties were conducted on each potting mix and on all components of the grower mix.
Both Tissue nutrient content and plant growth were analyzed weekly from each treatment to determine plant nutrient status. Based on this work, we can recommend specific protocols to organic tomato transplant growers to optimize seed germination, as well as transplant growth and nutrition utilizing either commercial or on-farm blends.

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 1840

Growers developed many new plantings of peaches across the state based on research and educational programs developed and provided by faculty. Full-time farmers looking for a means of diversifying their operations established many of these plantings, while other non-farmers established part-time peach operations. Research has demonstrated the potential profitability of peach plantings, with gross sales in excess of $8,000 per acre.

Farming system impacts on strawberry and tomato diseases and soil microbial ecology: short and long-term
Project 6641
Interdisciplinary, multi-state and participatory research, extension and educational programs are on-going to evaluate, adopt and develop alternatives to methyl bromide in strawberry and vegetable production systems. From 2000-2005, 43 Phase I trials (research conducted on research stations to evaluate new products or farming practices) and 27 Phase II trials (on grower farms) were implemented. Results were translated to key stakeholders through grower field days, agent training programs and presentations at extension conferences. More than 45 research and extension articles or abstracts were published. Stakeholders were informed at 15 field and agent training programs and through more than 29 presentations at grower meetings and commodity conferences. Research projects focused on development of integrated approaches to manage key soilborne pests.

Management of arthropod pests of turf and peanut
Project 6731
Studies continue to explore the abilities of turfgrass insect pests to avoid control strategies. Studies in North Carolina have refined our understanding of the life stages for three important species of white grubs and made progress on the use of nonchemical strategies. Mole cricket management research is contributing to use of fungal pathogens, while research in the Coastal Plain has allowed us to use newer chemistries to improve control of fire ants. The website “Turffiles” has been updated significantly and now includes weekly pest updates during the summer months. The Center for Turfgrass Environmental Research and Education continues to make progress and grow with the addition of federal funding and private corporate funding.

Ecology and management of European corn borer
Project 0205
Field research/demonstration plots were established to develop data relevant to Piedmont silage corn production that provided a rationale for replacing older insect control methods with seed treatments or rootworm resistant Bt corn. In 2005, western corn rootworm was the primary insect pest to infest the tests. Seed treatments showed significant benefit ($31 to $63/ac) vs. untreated corn, but the biotech Bt corn greatly exceeded all other treatments ($143/ac). Tests were used as a platform to demonstrate the utility and benefits of the new technology. Field tours, formal educational meetings, web-delivered information and one-on-one contact with influential growers and agribusiness persons were used to spread the story about the benefits of using seed treatments and/or Bt corn.

Weed management and growth regulators for agronomic crops
Project 6417
Growers who have adopted no-till and strip-till practices face a new challenge in controlling vegetation. Without tillage, this vegetation must be controlled chemically, and weeds such as cutleaf eveningprimrose have been a substantial problem. Based on our research, we have developed recommendations for effective and economical control of primrose and other common winter annual

weeds. This work has been instrumental in encouraging private industry to amend labels to fit these unique uses.

Economic decision support for sustainable ag products
Project 6528
Economists from North Carolina State University and RTI-International conducted an *ex ante* evaluation of swine farmers' perceptions of new waste management technologies. First, in-depth interviews were conducted with swine producers to collect qualitative information on perceived benefits and limitations of the current system. Next, based on the interview findings, a questionnaire was developed and mailed to a sample of North Carolina swine producers.

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.

Cultural management of strawberries and grapes
Project 6324
Working in conjunction with the Agronomic Division of the North Carolina Department of Agriculture and Consumer Services, new protocols were developed for tissue sampling in muscadine (Carlos variety) grapes.

Small fruit production systems
Project 6681
Partial budget analysis was used to evaluate the cost-effectiveness of alternative fumigants for the production of strawberries. The partial budget technique compared the negative effects of applying a new treatment relative to a base or standard treatment to the positive effects associated with the new treatment relative to the base or standard treatment. Therefore, it requires the consideration of both the returns of treatments and changes in the structure of the production costs. A budget was completed in 2005, reviewed and the final version was published in January 2006 in HortTechnology. Results were also presented at the North Carolina Strawberry Association annual meeting.

Integrated Peach Disease Management
Project 6160
For bacterial spot of stone fruits, it is important that spray applications be properly timed, taking into consideration that fruit are most susceptible immediately following bloom. Infection of fruit also is closely related to specific periods of moisture. A model is being developed with the objective of better timing spray applications and understanding of the disease epidemiology. Studies also have been done to better understand the basic biology of X. arboricola pv. pruni. Although host resistance is available for bacterial spot of peppers, this resistance has been defeated by the selection of new pathogen races. Research is ongoing to better understand the forces that drive the selection process leading to defeat of the host resistance.

Management of arthropods on fruits and vegetables and Western North Carolina

Project 6402
North Carolina State University researchers cooperated with colleagues at six other land grant universities in the Eastern U.S. on a project to develop and implement reduced-risk pest management programs for eastern tree-fruit growers. By relying on the use of new reduced-risk insecticides and mating disruption, this project demonstrated that apple insect pests can be adequately controlled using reduced-risk strategies. The higher cost of this new technology represents a 2 percent increase in production costs to growers. Additional research is underway to reduce the cost of these programs.

Best Management Practices for Anti Gibberellins in Floriculture Production
Project 6718
Working with GrowerTalks magazine, North Carolina State University floriculturalists developed a plant growth regulator production guide. This guide provides the latest information about optimal rates for applying plant growth regulators.

Biological control of arthropod pests in weeds
Project 0303
Studies of commercially available beneficial insect habitat seed mixes provided growers with much-needed guidance on whether to use these products, and if they choose to, how best to plant them. A simple, easy-to-use method was implemented to increase dramatically the lifespan of parasitic insects released for insect pest management. Ongoing work comparing insect populations in organic and conventional cropping systems will provide organic growers with sorely needed information on insect management. Ongoing studies on beneficial insect habitat will also provide organic growers guidance on how to select habitat plants to improve insect management systems.

Risk aversion, risk shifting and alternative payment mechanisms in settlement of broiler contracts
Project 6527
A study showed no empirical support for the proposition that broiler processors may be systematically discriminating among contract growers of different abilities when supplying them with variable quality production inputs. This result should serve as a valuable argument in resolving frequent disputes between integrators and growers and should serve as a vehicle for future trust building.

Use of alternative supplements in grazed, hayed and ensiled forage systems for beef cattle
Project 6736
Byproduct feeds remain an important part of beef cattle feeding programs both in North Carolina and in surrounding states. Applied research showed that both dry and wet corn gluten feed are economically viable feed ingredients for use in beef finishing diets. This information led to increased adoption of those ingredients in cattle diets.

Developing Strategies for Improved Pasture Fly Management
Project 6803
Faculty evaluated an experimental electric walk-through flytrap designed to reduce horn fly populations on cattle and the NZI biting fly trap designed to aid in the management of stable flies on pastures. Faculty also focused on dung beetle ecology and identified dung beetle-compatible fly management strategies. In addition to dung beetles rendering dung pats unsuitable for horn fly development, beetles also improve pasture condition and increase soil percolation and nutrient cycling.

Nutritional strategies to improve the growth, productivity and profitability of dairy cattle
Project 6605
Lactoferrin, an iron binding glycoprotein obtained by separation from the whey protein fraction of bovine milk, has been shown to have antimicrobial properties. A study was conducted to determine the effect of feeding whole milk supplemented with either 0.5 gram or 1 gram of lactoferrin versus whole milk with no added lactoferrin on growth and health of Holstein calves weaned at 35 days of age with post-weaning supplementation of lactoferrin continued through 56 days of age.

Improving reproduction and management of dairy cattle
Project 6600
More and more producers have sought and received information on use of crossbreeding in dairy cows. It is expected that more than 30% of NC dairy farmers either currently are using some crossbreeding or have some interest in use of crossbreeding in their herds. As part of the project, NC State University is conducting a long-term dairy crossbreeding study in collaboration with Virginia Tech and the University of Kentucky. Initial data from our work will be presented at the 2006 summer meeting of the American Dairy Science Association.

Use of feed additives to reduce aflatoxin transfer to milk.
Project 6778
Mycotoxins affect dairy cattle production by reducing milk production, reducing reproductive efficiency and increasing morbidity and mortalities. North Carolina dairy producers have been made aware of and are adopting practices to minimize mycotoxin problems.

Genetic approaches to enhance efficiency and profitability of pork production
Project 6792
A study to document for most traits of economic interest, changes over the last 25 yr and the relative contribution that nutrition and genetics have made to those changes. Preliminary data suggest that genetic improvement has occurred in structural correctness and mobility; however, changes in feeding programs have resulted in reduced mobility. Furthermore, commercial pigs from 2005 were more aggressive toward a foreign pig than commercial pigs from 1980. One interpretation of this result is that selection for increased lean growth rate has resulted in correlated changes in behavior. In addition, 2005 genetic line pigs fed 2005 diets were 20% faster growing than 1980 genetic line pigs fed 1980 diets. However, when 1980 genetic line pigs were fed 2005 diets or conversely 2005 genetic line pigs were fed 1980 diets growth rate did not differ indicating that genetics and nutrition have made equal contributions to advances in growth rate. The 2005 genetic line pigs were leaner regardless of feeding program indicating a 14% reduction in backfat due to genetic improvement. However, loin muscle areas were improved due to both genetic and nutritional changes. Preliminary evaluation of subjective pork quality measures indicates that modern nutritional programs have had a negative impact on quality when applied to modern genotypes.

Nutritional approaches to enhance swine production efficiency and profitability
Project 6777
Faculty evaluated whether Mg supplementation through the water would impact pork quality in pigs. Research determined that supplementation for as short as two days could impact pork quality, regardless of dose of supplementation. This work demonstrated large differences in pork quality between genotypes but did not detect effects of Mg on pork quality in these genotypes. These studies determined that the effects of Mg on pork quality vary and cannot be explained by variation in

growth rate of pigs or genetic predisposition to poor pork quality. Currently, efforts are ongoing to evaluate the potential impact of Mg supplementation on pork quality under commercial conditions and at several commercial packing plants.

Maximization of laying hen performance, economic return and egg quality
Project 6184
The National Egg Products School provides plant personnel, quality assurance supervisors and middle management within the egg-breaking industry current information on what constitutes egg product quality, how to measure it, and important issues facing the egg industry in the region.

Fish food ingredients produced by solubilization/reprecipitation
Project 6616
Proper chilling of fish on-board the boat was studied to determine the prevalence and type of spoilage bacteria capable of producing histamine. This information was compiled and incorporated into model seafood safety plans for use by commercial and recreational fish harvesters. The information along with current regulatory guidelines is posted at http//:www.iceyourfish.seagrant.org. In addition, workshops are available through the various cooperative extension and sea grant offices.

Strategies to increase meat goat production
Project 6701
The North Carolina State University Meat Goat Program partnered with the North Carolina Department of Agriculture and Consumer Services, North Carolina A&T State University, North Carolina Cooperative Extension and the North Carolina Meat Goat Producers, Inc. to organize and launch a meat goat marketing organization. Several training and certification courses were provided as part of this effort, which allows meat goat producers to market live goats and goat meat directly to consumers and area retail stores and restaurants, thus eliminating middlemen and goat traders.

Integrating crops and livestock systems
Project 6602
The Center for Environmental Farming Systems is providing educational activities for students, agricultural professionals and farmers. CEFS research is providing important information on organic production practices, long-term systems research and training opportunities for students and agricultural professionals. Special emphasis is being placed on outreach, and CEFS is serving as a regional model for sustainable agriculture research and education. In 2005 a wide range of groups and organizations visited the center, including international as well as national and local visitors with an interest in sustainable agriculture research and education.

Fish Responses to Biotic and Abiotic Factors Affecting Behavior, Growth and Survival
Project 7257
Research showed that poor summer habitat conditions that force striped bass into water temperatures above 27 degrees Celsius do not necessarily result in poor growth and condition. Rather, the abundance of the food supply plays a major role in determining growth. Striped bass forced into unfavorably hot temperatures do have much higher metabolic costs, but if food supplies are adequate, they can still survive and grow quite well. Depending on the combination of conditions, food availability is much more important than summer temperatures in some reservoirs, while in others, temperature has the larger effect on growth. Using the approach we have developed, along with system-specific information on summer habitat conditions and forage fish populations, fisheries

managers can now tailor their striped bass stocking and harvest management strategies for individual reservoirs to optimize each fishery.

Mountain aquaculture research
Project 6153
Faculty designed and coordinated an effort to obtain samples of farm-raised rainbow trout from commercial facilities in the primary trout production states across the United States. Sampled trout were ready for market and were from 12 to 18 months of age. Information was also gathered about feed sources, water supply and proximity to any potential source of mercury discharge, such as waste sites or coal-burning industries. Trout samples were analyzed for mercury content. In every case, mercury content was orders of magnitude below the action limits set by FDA (1.0 ppm) or by EPA (0.3 ppm).

Average mercury content in trout meat was 0.013 ppm with a range from <0.001 to 0.030 ppm in all samples, placing it among the very lowest in popular seafood species. There was no difference between locations or facilities, and all samples were actually below the legal reportable limit for the analytical method used (EPA Method 7470A; legal reportable limit 0.05 ppm).

Economics of the Soybean Complex and the Impact of Changes in Technology, Processing, Policy, and Trade
Project 6781
New farm policy is slated to be enacted in 2007, and the current economic climate calls for significant budgetary cuts of current programs. The challenge to policy-makers is how to accomplish these budget cuts without deviating or compromising the goals of farm policy. Faculty outlined the current economic environment and farm policy as well as recommendations for policy reform in testimony before a subcommittee of the House Agricultural Committee in September 2005. This statement made the point that to be successful, U.S. farm policy should include three critical elements: (a) an economic safety net; (b) the adoption of state-of-the-art production technologies; and (c) the mitigation of the over-reliance of some agricultural commodities on government payments. Each of these elements was discussed, and empirical evidence of the state of the agricultural economy was utilized and referred to where appropriate.

Economics of adoption of agricultural technologies
Project 6610
The Conservation Security Program rules for payments for enhanced practices are presented by the State Conservationist of the Natural Resources Conservation Service to the State Technical Committees each year for revision and approval. These rules determine the practices and payment amounts per acre farmers can receive for environmentally beneficial practices on their farms. Acting as an advisor to the North Carolina State Technical Committee, a North Carolina State University agricultural economist discovered a problem with the list of enhanced practices for 2006. The section of the rules regarding Pest Management Enhancements excluded growing biotech crops as an approved practice. The advisor argued successfully to have biotech crops included in the enhancements list at a $10 per year payment.

GOAL 2 A SAFE AND SECURE FOOD AND FIBER SYSTEM

Enhancing food safety through control of foodbourne disease agents	**0295**
The poultry food system: A farm-to-table model	**0292**

Enhancing food safety through control of foodborne disease agents
Project 0295
Poor sanitation programs can costs a large food processors $250,000 to $500,000 per year in water consumption, wastewater treatment, and lower product quality. A 3-credit, computer based food sanitation course (FS 495K) has been developed for industry and on-campus students. Over the past three years over 50 industry persons have taken the course, and Tyson Foods has incorporated this course into their management training program. In 2004, 20 industry persons were trained in food sanitation practices from large meat processing plants. Their estimated cost savings from improved sanitation programs would be $5 to $10 million dollars.

The poultry food system: A farm-to-table model
Project 0292
Research showed that ovotransferrin, lysozyme and β-N-acetylglucosaminidase located in egg shell membranes are the primary components responsible for antibacterial activity against selected foodborne disease-causing bacteria. The combination of these proteins and perhaps other egg shell membrane components interfere with the normal structure and function of bacterial cell membranes, increasing their sensitivity to heat and possibly pressure and osmotic stresses. Purified proteins from hen egg white also produced a similar but greater cellular response than the egg shell membrane-bound components. Although differences were seen in the enzymatic activities of these components across layer breeds and ages, it did not adversely impact their inhibitory activity against *Salmonella* Typhimurium.

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 NC	**6752**

Insect and manure management in poultry systems: Elements relative to food safety and nuisance issues
Project 1006
Our efforts have focused on fly transmission of Newcastle disease virus. We have developed and demonstrated a unique trapping system to collect flies for pathogen monitoring. We have demonstrated that house flies are capable of harboring Newcastle disease virus beyond 96 hours and

virus titer decreases with time. House flies are capable of transmitting New Castle Disease Virus if the fly carries an infectious oral dose above 10^6. Results indicate that the house fly role in viral disease transmission is directly linked to infectious dosages acquired within 3 hours. We identified risks for the poultry industry relative to the practice of mixing insecticides and disinfectants to control poultry pests and sanitize poultry houses. Such practices reduced the efficacy of many commonly used chemicals. Results of this study clearly demonstrate the implications for the spread of pathogenic agents. A NIH proposal has been submitted to further study the role of house flies in the detection and transmission of Avian Influenza.

Biology and control of nuisance vector arthropods in North Carolina
Project 6752
Bacterial species that produce metabolites that mediate the oviposition responses of the disease vectors Aedes aegypti and Aedes albopictus are being identified. Researchers previously established that gravid females use volatile metabolites produced by the bacterial community in mosquito habitats as semiochemical cues to locate containers for egg laying. Researchers have captured volatile chemicals from these bacteria that mediate mosquito oviposition. These odorants are being identified by GC/MS. Once they are identified, the chemicals will be formulated into a lure that can be used to increase the effectiveness of traps used for surveillance or control of container-inhabiting mosquitoes.

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

Environmental nursery crop production	**6224**
Evaluation and modeling of riparian buffer performance in the Neuse River Basin	**6609**
Precision agriculture for agronomic crops and nitrogen management for corn in Eastern North Carolina	**6652**
Improving sediment and erosion control measures	**6559**
Evaluation of Tillage Practices, Organic Production, and trickle Fertigation for Nutrient Management	**6648**
Development of plant pathogens as bioherbicides for weed control and weed management in landscapes	**1001**
Nutrient and by-product utilization and health of turkeys and broilers	**6343**
Effect of management on turkey production, turkey reproduction and turkey waste handling	**6390**
Improved efficiency of water reuse aquaculture systems	**3975**
Engineering processes to enhance nutrient management and reduce environmental impacts of animal manure	**6575**
Evaluation of soil and site Evaluation BPM's for On-site Wastewater Systems in Seasonally Saturated Soils.	**6800**
Performance of on-site wastewater system and other land-based technologies for Low Impact Development (LID)	**6793**

Aquaculture of southern flounder and improved water quality management of ponds in eastern NC.	**6387**
Best Management Practices and Nutrient Reductions	**6716**

Environmentally compatible nursery crop production practices
Project 6224
A study compared growth and survival of *Cornus ammom* (Silky Dogwood) seedlings grown in three container substrates. Water use was monitored through the growing season, and plants counted for survival and measured for height at the end of season. Plant height and caliper were improved by each introduced treatment compared to the nursery's standard, and plant loss was reduced. The nursery learned that they could improve plant response at the same time they were improving water use efficiency. For a nursery to reduce water use and improve plant growth allows greater flexibility in nursery layout, increased water conservation and less environmental impact due to over irrigation to compensate for poor water retention of potting substrates .

Evaluation and modeling of riparian buffer performance in the Neuse River Basin
Project 6609
Working with local landowners, North Carolina Cooperative Extension developed nutrient management plans for nearly 25,000 acres and installed more than 100 water control structures to implement controlled drainage on approximately 5,000 acres in the Core Creek Watershed over the past six years. The hydrology and surface water quality associated with these best management practices were monitored at approximately 60 locations throughout the watershed. Outflow was measured continuously and drainage grab samples were collected monthly and analyzed for nutrients such as nitrogen and phosphorus. The data were used to calibrate water table management hydrology and nutrient model, DRAINMOD-N. DRAINMOD-N was then used to simulate the long- term water quality benefits of nutrient management and controlled drainage. Approximately 1,600 feet of a channelized stream was restored, and the site is being performance monitored for hydrology, water quality and habitat functionality.

Precision agriculture for agronomic crops and nitrogen management for corn in Eastern North Carolina
Project 6652
Guidelines for soil fertility management are under development in support of kenaf and organic grain production systems. Statewide, kenaf acreage increased to approximately 5,000 acres in 2004. Transitional organic grain acreage increased to 50 acres in Hyde County and is expected to increase as a planned poultry layer operation provides a locally abundant organic fertility amendment.

Improving Sediment and Erosion Control Measures
Project 6559
Efforts continued to provide the construction industry with alternative erosion and sediment control methods. One entrepreneur is developing our initial efforts to introduce polyacrylamide in solution to turbid water for a fast, reliable flocculation reaction. We have also established methods for reducing turbidity in stilling basins using polyacrylamide; established methods for improving sediment basin performance using porous baffles through detailed measurements; and installed the first alternative riser barrel (flashboard riser) in a sediment control basin.

Evaluation of tillage practices, organic production, and trickle fertigation for nutrient management
Project 6648
Conservation tillage systems were developed that reduce or eliminate water and soil runoff from farm fields. A majority of farmers across Western NC have adopted these conservation tillage practices for corn production. Farmers have also started to use these methods for growing tobacco and vegetables.

Development of Plant Pathogens as Bioherbicides for Weed Control and Weed Management in Landscapes
Project 1001
Currently no biological control options are available for weeds of urban landscapes. Experiments were initiated in 2005 to evaluate the endemic wood-rotting fungus, Chondrostereum purpureum, as a biological option for woody weed control. Several invasive woody weeds were planted in early 2005 and treated in the fall. This biocontrol candidate was also evaluated on established hardwoods and Oriental bittersweet vines.

Nutrient and by-product utilization and health of turkeys and broilers
Project 6343
The potential of two antibiotic growth promoter alternatives was evaluated by several experiments aimed at improving gut health of broilers and turkeys. The effect of dietary supplementation of egg immunoglobulins (IgY) produced from hens immunized against Salmonella spp. was studied on the growth and immune response of both salmonella-challenged and unchallenged broiler chicks. Dietary IgY increased growth and meat yield in challenged birds, and it suppressed the inflammatory response associated with enteric disease. Other experiments evaluated the effect of dietary enzyme and grain formulation on intestinal health of turkeys and broilers. Wheat-based diets supplemented with enzyme resulted in a more stable and diverse gut microflora than corn-based diets, resulting in greater resistance to salmonella colonization and enteric disease.

Effect of management on turkey production, turkey reproduction and turkey waste handling
Project 6390
Studies tested the efficacy of nipple drinkers for rearing turkeys. Birds on nipple drinkers had reduced body weights, particularly during the time of most rapid growth. Feed conversion was not initially effected by drinker type. Feed consumption was not reduced by nipple drinkers until the last period of the first trial. Feed consumption was reduced for some systems throughout trial two. Litter moisture beneath the drinkers in trial one was affected at 6 and 20 weeks. Some drinker systems resulted in lower litter moisture, while others resulted in higher litter moisture. The results of this study concur with the results of other studies that were similarly conducted. Nipple drinkers can be an alternative to traditional open watering systems, particularly during the brooding period up until 6 weeks of age. Some systems can be used to rear turkeys all the way to market age. In addition, a combination of nipple drinkers during brooding and open watering systems during grow-out may also be successful.

Improved efficiency of water reuse aquaculture systems
Project 3975
Major advancements were made at the North Carolina Fish Barn in the development of wastewater and solid waste treatment for recirculating aquaculture production technology. The goal of this project was to reduce the organic solids load of the waste stream leading to the effluent holding pond.

What has been accomplished is a waste reduction so complete that it may soon be possible to completely reuse the wastewater in the production system.

Engineering processes to enhance nutrient management and reduce environmental impacts of animal manure
Project 6575
Faculty conducted evaluations and served on advisory panels that are part of an effort to evaluate and develop new swine waste management technologies. These evaluations identified five technologies that are considered "environmentally superior" to the lagoon and spray field technology per agreements between the North Carolina Attorney General's Office and Smithfield Foods, Premium Standard Farms and Frontline Farmers.

Evaluation of soil and site Evaluation BPMs for On-site Wastewater Systems in Seasonally Saturated Soils
Project 6800
The current BMPs for siting on-site wastewater systems may lead to premature failure of the systems. Research showed that the current method of assessing soil wetness overestimates the depth to seasonal wetness. Seasonal wetness is a major cause of system failure, thus overestimation of its depth results in systems being installed too deep in the soil and subject to premature failure.

Performance of on-site wastewater system and other land-based technologies for Low Impact Development (LID)
Project 6793
A study identified which specific operation and maintenance factors have significant effects on wastewater system failure rates and also showed which factors don't influence failure rates. It was clear that post-installation inspection would alleviate some of the problems observed. Also, providing long-term protection and maintenance of the location where the system was installed and the immediate area around it (site maintenance) significantly reduced failure rates and was one of the important factors that must be addressed in order to keep the system failure rates low.

Aquaculture of southern flounder and improved water quality management of ponds in Eastern North Carolina
Project 6387
Faculty have succeeded in the establishment of XX males for use in producing all-female southern flounder fingerlings. Our research has also established the first commercial-scale data on growout characteristics with a full economic analysis of the results. These accomplishments are fundamental steps in the commercialization of flounder culture and will lead to maximizing the economic viability of flounder farming.

Best Management Practices and Nutrient Reductions
Project 6716
A Nitrogen Loss Estimation Worksheet (NLEW) was developed to track nitrogen changes from agricultural activities within the Tar-Pamlico River Basin. The NLEW tool was updated to include vegetable crops, since large acres of vegetables are produced in the Tar-Pamlico Basin.

GOAL 5
ENHANCED ECONOMIC OPPORTUNITY AND QUALITY OF LIFE FOR AMERICANS

Economics of socially optimal pork production	**6706**
The public economics of fast growing regions	**6532**
Rural communities, rural labor markets and public policy in North Carolina and the Southeast	**1011**

Economics of socially optimal pork production
Project 6706
Faculty conducted economic analyses of alternative manure management systems being evaluated through the North Carolina State University Animal and Poultry Waste Management center and the North Carolina Attorney General's agreements with Smithfield Foods, Premium Standard Farms and Front Line Framers. Systematic evaluation of the expected costs and returns to 19 technologies was completed in 2004 and 2005. This information 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
The contribution of agriculture and agribusiness to the state economy is measured annually. Similar measures have been developed for each of North Carolina's 100 counties. These statistics show a very large contribution from agriculture and agribusiness to the state and county economies.

Rural communities, rural labor markets and public policy in North Carolina and the Southeast
Project 1011
One important element of public debate over appropriate land use policies is whether or not increased local government expenditures on community services needed to accommodate residential and commercial development exceed the contribution of that development to the local revenue base. Research has quantified the contribution to local government revenues of various types of land uses (residential, commercial/industrial, and agricultural) and the demands on local government financial resources of those same land uses. These "snapshots" of current revenues and expenditures allow an assessment of the costs and benefits of different land uses from the perspective of local government finance.

Summary:

Research-Extension Integrated Project Initiatives involved 71 projects with Hatch Funding Sources involved in support of 62 Scientists who led projects.

Total Hatch funding allocated and expended on 62 projects for FY 2005: $1,800,252

Total Hatch budget allocation for 2005 was $6,162,030.

Percent of total Hatch funds allocated to Integrated projects amounted to 29.22%

U.S. Department of Agriculture

Cooperative State Research, Education, and Extension Service

Supplement to the Annual Report of Accomplishments and Results

Actual Expenditures of Federal Funding for Multistate Extension and Integrated Activities

(Attach Brief Summaries)

Fiscal Year: 2005

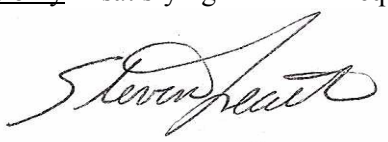
Select One: **Interim** **X** **Final**

Institution: NC Agri. Research Service

State: North Carolina

		Integrated Activities (Hatch)		Multistate Extension Activities (Smith-Lever)		Integrated Activities (Smith-Lever)	
Established Target %		25	%		%		%
This FY Allocation (from 1088)		$6,162,030					
This FY Target Amount		$1,540,508					
Title of Planned Program Activity							
Goal 1	An Agricultural System That is Highly Competitive in the Global Economy	$1,404,323					
Goal 2	A Safe and Secure Food and Fiber System	$31,100					
Goal 3	A Healthy, Well-Nourished Population	$51,905					
Goal 4	An Agricultural System That Protects Natural Resources and the Environment	$401,199					
Goal 5	Enhanced Economic Opportunity and Quality of Life for Americans	$87,850					
		$1,800,250					
	Total	$6,162,030					
	Carryover	$259,742					

Certification: I certify to the best of my knowledge and belief that this report is correct and complete and that all outlays represented here accurately reflect allowable expenditures of Federal funds only in satisfying AREERA requirements.



3-20-2006

Director **Date**