

North Carolina Agricultural Research Service

Annual Report of Accomplishments and Results

2004

AREERA REPORT

Agricultural Research, Education, and Extension Reform Act

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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 2004 NCARS personnel include 285 tenured and tenure-track research faculty accounting for approximately 187 full-time scientist equivalents, most on shared appointments with academics or extension. Working with these faculty members are over 446 research professors, researchers, research assistants and graduate students, 452 laboratory and field technicians and 165 clerical staff. These faculty members and support personnel conduct basic and applied research in 637 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 2000-2004 Plan of Work, 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 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. Achievements include:

- Production and post harvest information on new greenhouse and field-grown cut flowers such as *Campanula*, *Euphorbia*, *Trachelium*, *Lupinus*, *Linaria*, *Papaver*, and others was developed.
- The effect of the high-oleic fatty acid trait on peanut seed's capacity to support production of aflatoxin when infected by *Aspergillus* fungi during storage was determined. High-oleic peanuts supported nearly twice as much post-harvest aflatoxin production as peanuts with normal oil chemistry.
- Use of 1-methylcyclopropene, an ethylene inhibitor, was found to extend the shelf-life of yellow, ripening bananas by approximately 4-5 days.
- Through ethylene action inhibition, using 1-methylcyclopropene, it may be possible to save apple storage energy costs by raising the storage temperature a few degrees.
- Sliced apples were treated with approved food grade compounds to stop browning and firmness was maintained with 1-methylcyclopropene, an ethylene action inhibitor, resulting in a product that could be sold as value-added item. This could benefit the growers by increasing sales and the consumers by providing a high quality, nutritious convenience food.

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.

- Using aerial color infrared photography to better determine when, where, and how much nitrogen fertilizer to apply to corn and wheat was shown to increase profitability and minimize environmental impact.
- A biologically-based pest management system for cutleaf evening primrose was completed that maximizes herbicide performance, thus minimizing herbicide use. Glyphosate was shown to reduce pollen viability in glyphosate-resistant corn, thus potentially leading to lower yields.
- Increasing seeding rates of corn was shown to increase yield 3 bushels/acre for each 1000-plant increase/acre up to 34,000 plants/acre.
- NCARS scientists in the NCSU Micropropagation unit, the Sweetpotato Breeding Program and the Cultural Management Program produce high quality sweetpotato seedstocks that are used by at least 90% of the growers in N. C. and are distributed to growers in all the sweetpotato growing states in the U.S. Additionally “specialty market” clones are being produced for niche markets.
- Turfgrass was found to prevent the downward leaching of some pesticides applied during periods of rapid growth.
- The economic thresholds for volunteer Clearfield corn (imidazolinone-tolerant), Palmer amaranth, and jimsonweed in peanuts were determined.
- Starter fertilizer with additional potassium was found to increase the rooting depth of small grains 1-3 inches, root volume and grain yield by 10-15 bu/acre.
- Weed ecology studies on the yield loss associated with evening primrose in cotton were completed, and the critical period of weed control and weed biomass relationships were determined for the next generation of Roundup resistant (“Flex”) cotton.

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

- The new potato variety, Harley Blackwell, released in cooperation with the USDA-ARS in 2003/2004 is less susceptible to internal heat necrosis, a major problem in the mid-Atlantic and Southeastern U.S.
- The newly released, improved sweetpotato cultivar, Covington, released by NCARS scientists, was grown on over 500 acres with estimated farm-gate revenues of \$900,000.
- A very high genetic correlation was found between Fusarium ear rot and accumulation of the mycotoxin fumonisin, suggesting that visual selection against ear rot would be effective in reducing susceptibility to mycotoxin contamination.
- Fourteen transgenic peanut lines were developed in the peanut “Georgia Green” carrying a transgene encoding ASP1, a protein that is high in four amino acids, which are usually deficient in peanut.
- ? A newly registered synthetic cytokinin material (6-BA) showed great promise as a post-bloom thinning material on Fuji and Gala apple varieties. When applied at reduced rates in combination with carbaryl, this mixture typically thinned trees to a commercially acceptable level, leaving most of the remaining fruit as singles (one fruit per spur).

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

- Bermudagrass and perennial ryegrass were shown to have superior rooting ability in compacted soil compared to St. Augustine grass. This research highlights the nature of soil compaction so that landscapers may better understand soils at new construction sites.
- A proactive certification nutrient management program was developed for turfgrass species in North Carolina.
- ? The development of biological control strategies for use in the turfgrass system has been enhanced by an improved understanding of pest behavior in association with the presence of various control agents. Formulations and strains of biocontrol agents were shown to significantly impact their efficacy.

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.

- Sweet Caroline Red, the fifth in a series of ornamental sweetpotatoes for the urban landscape was released.
- Protocol for the nursery production of containerized Atlantic white cedar seedlings was developed, along with protocols for improved regeneration methods, seedling production practices, and seed utilization.
- An accession of bloodroot (*Sanguinaria canadensis* DAD30) was found to have a unique “staghorn” leaf form, making it attractive for propagation as an ornamental.
- Six world-class plant collections have been included in the J.C. Ralston Arboretum overall planting. They include Mahonia, Hydrangea, Nandina, Styracaeae, Viburnum, and Cercis .
- ? J.C. Ralston Arboretum and the North Carolina Association of Nurserymen are working together to develop a Premiere Plant Introduction Program. Three plants are expected to be introduced in August 2005.

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, with faculty 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 to waste byproducts, while also protecting the environment. The waste management systems currently being used on North Carolina swine farms are under critical review by state and federal regulatory agencies and many

other stakeholder groups that impact the sustainability of this animal agriculture industry. Objective evaluation of the present systems and development of alternative swine waste management systems that are economically feasible are critical to the continued vitality of North Carolina's swine production industry and to maintain the state's environmental health. A large number of research efforts have been described in a Technology Determination Report (issued on July 26, 2004). This report, "*Development of Environmentally Superior Technologies: Phase 1 Technology Determination Report*," published by NCSU College of Agriculture and Life Sciences, is on file with NCSU Animal and Poultry Waste Management Center (July 26, 2004). Sponsored projects include:

- decommissioning of anaerobic lagoons;
- stabilization of manure nutrients in soil;
- co-combustion of animal manure for energy recovery;
- development of farm-level odor reduction systems;
- development of methodologies for the handling of animal mortalities to convert them to value-added feed grade products;
- assessment of alternative bedding and litter products for use by the poultry industry;
- commercial scale development and environmental performance standard verification involving emissions of odor, pathogens, emissions of ammonia as well as economic feasibility analysis for approximately 20 experimental animal waste technologies.

Improving animal health and production efficiency was addressed.

- Dairy cow nitrogen excretion was reduced 18% while maintaining milk production by feeding a lower crude protein diet in which the protein was less degradable in the rumen and was balanced for a 3:1 ratio of the amino acids lysine and methionine.
- Developed feeding regimes for cultured hybrid striped bass that induce repeated compensatory growth stages and improve feed conversion efficiencies, thereby reducing production costs ~ 10 –15%.

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

- NCSU apiculturists found that increased mating numbers by honey bee queens reduce the likelihood of severe infections by numerous parasites and pathogens. These results may help decrease the impact of disease on honey bee colonies, which are responsible for pollinating approximately one-third of the crops in the U. S., accounting for an additional \$15 billion each year in increased yields.
- With the use of economic models and producer surveys, this work was instrumental in assuring that EPA's new effluent guidelines were based on sound science and would provide environmental protection as well as allowing continued economic viability for the U.S. trout aquaculture industry.
- More than 3000 tons of recycled poultry bedding, 7000 tons of soybean hulls, 4500 tons of dry corn gluten feed and 8000 tons of wet corn gluten feed, and 5000 tons of other miscellaneous byproducts were utilized by beef cattle producers for a realized savings of more than 1 million dollars.

- Collaborative research has resulted in the first F.D.A. approved product for estrus synchronization in mature swine. Reproductive performance, sow longevity, and profitability all increased, potentially saving the U.S. swine industry \$30 to \$90 million in management errors.
- Appropriate dietary supplementation of enzymes, amino acids and organic minerals to poultry feed have been demonstrated to reduce the excretion of phosphorus, nitrogen, and other minerals by improving diet digestibility more than 5%.
- Developed methodology for controlling gender in cultured southern flounder. Production of 100% female populations, which grow at 2-3 times the rate of males, reduces production cost by ~25%.

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

- Cockroaches are the most important arthropod pest in swine production. Severe infestations significantly contribute to disease maintenance and transmission. A new pest management program based on low-risk insecticides, insect growth regulators, and biological control agents was developed. This program reduced by 90% both insecticide use and labor costs associated with pest control.
- Fifty percent of composite litter and fecal samples from broiler farms were positive for *Salmonella*. While individual farm, season, or flock age did not affect *Salmonella* populations or their prevalence on commercial broiler farms, these factors did influence *Salmonella* populations collectively. On-farm strategies such as using older litter or litter treatment and management will ultimately lead to a reduction in the contamination level of flocks entering broiler processing plants.

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
\$4,443,733.15	\$23,531,700.70	\$2,630,523.81	\$6,352,111.68	104.3	237.02	244.1	37.7

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.

b. Impact: Recent research on corn seed coating technology has lead to significant reductions of older, more toxic, and environmentally damaging granular soil insecticides. On a per field basis,

active ingredient use has declined by 92% to 99%. Simultaneously, protection of planted corn seed and small seedlings from insects has been improved

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

Key Theme: Urban Gardening

a. Issue. Urban gardening is expanding in popularity as urban consumers seek to capture a component of the rural environment, that entails openness, and a natural environment. NCARS scientists are identifying and selecting new plants to enhance urban gardens.

b. Impact: The “Sweet Caroline” series of ornamental sweetpotato is on its way to becoming “the” ornamental sweetpotato of choice in the landscape industry with the release of “Sweet Caroline Red,” the fifth clone in the series, during 2004. Plantings are growing rapidly in many major urban markets. U.S. plant patents are granted or pending on Sweet Caroline varieties, and Canadian, European Union and Japanese plant patent applications are in the works. Bodger Botanicals, South El Monte, CA, who have the exclusive marketing rights to these varieties, report plant sales exceeding 1.2 million units in 2004, with gross retail value estimated to be over \$3.5 million after two years of sales.

c. Scope of impact - national

Key Theme: Ornamental/Green Agriculture

a. Issue: Nursery/floriculture crops have been the fastest growing agricultural sector in North Carolina over the last 15 years. The wholesale value of these crops exceeds \$1 billion – far surpassing tobacco as the number one crop commodity in North Carolina. In addition to economic impact, these crops play a vital role in enhancing and protecting our environment as natural areas continue to be lost to expanding development and urbanization. Continued research has led to the development of improved crops with greater adaptability, pest resistance, and commercial potential in order to improve the competitiveness and profitability of this industry and improve the environmental quality of our planet. Recent introductions of new plants include ‘Venus’ sweetshrub, ‘Shiloh Splash’ river birch, and ‘Summer Cascade’ river birch.

b. Impact: Identification and development of superior plants and germplasm with greater adaptability and pest resistance are contributing to reduced need for pesticides, improved environmental quality, and greater value for both producers and consumers. For example, research on selection and development of pest resistant plants has essentially eliminated the need for pesticides to control apple scab, dogwood anthracnose, fire blight, powdery mildew, Japanese beetles and Eastern tent caterpillar on a variety of plants. Continued development of new nursery crops has considerable economic potential. One exceptional new nursery cultivar can potentially generate wholesale sales of \$1-\$2 million annually. Retail sales, including installation, can potentially be twice that amount.

c. Scope of Impact – State and National

Key Theme: Plant Germplasm

a. Issue: Apple production in the Southeast has been steadily declining over the past three decades. North Carolina had 16,196 acres of apples in 1976 and only 6,962 acres in 2001. (source: North Carolina Department of Agriculture and Consumer Services Agriculture Statistics Summary 2002). The future of the apple industry in the Southeast will depend on the willingness of apple growers to develop new markets, produce newer fresh market varieties that are uniquely suited to production in the region, and adopt production technologies that improve yield consistency and fruit quality.

b. Impact: This project, in collaboration with the NE183 regional apple project, identified several new fresh market varieties that are suited to environmental conditions in the Southeast, including Ambrosia, Cameo, September Wonder, Suncrisp, Autumn Gold and Honeycrisp, which will fit roadside, state and regional marketing opportunities.

Scope of Impact – State and regional

Key Theme: Emerging Diseases

a. Issue: Exotic pests have caused extensive damage to U.S. forests, agriculture, aquatic systems and the general environment since foreign population migrations began centuries ago, but the risks have been greatly increasing with the new global economy. The ability to predict the areas where new pests are likely to establish is essential to the security of U. S. agriculture.

b. Impact: NCARS and APHIS scientists are developing NAPPFAST (NCSU/APHIS Plant Pest Forecast System), a tool for the weather-based risk assessment of plant pests. The NAPPFAST system can be used to predict the likely establishment potential of exotic plant pests based upon climatic averages or forecasts at a spatial resolution of 10 km or finer. After the detection of soybean rust in November 2004, NAPPFAST in conjunction with a related project on soybean rust, predicted the initial distribution of the disease based on tropical storm activity.

c. Scope of impact - National

Key Theme: Plant Health

a. Issue: Forecasting the occurrence and severity of outbreaks of pests can help farmers avoid catastrophic losses and reduce the dependence on pesticides. Several NCARS projects are investigating the development and utility of forecasts for such diseases as downy mildew of cucurbits, Alternaria blotch of apples, soybean rust, tobacco blue mold and tomato spotted wilt virus.

b. Impact: A tomato spotted wilt virus index for peanuts has been developed based upon the Georgia system. The index uses cultural practices to minimize the impact of this disease on peanut production in the Virginia-Carolina production area. The adoption and utilization of this index by peanut farmers has produced a reduction in the incidence of this disease in N.C. peanut fields of greater than 50%.

c. Scope of impact: regional and national

Key Theme: Organic Agriculture

- a. Issue: In recent changing dynamics of crop production and marketing systems and pressures exerted on tobacco production have resulted in major farm profit fluctuations and uncertainty, which has been the catalyst for the redirection of programs within NCARS to examine ways to intensify the diversify of crop production in North Carolina. These studies have led to the increased interest in the production of organic produce. A challenge to the production of organic crops in North Carolina is the diversity of pests.
- b. Impact: Three commercial and three non-commercial beneficial insect habitat seed mixes were evaluated for organic crop pest management. One commercial mix was infested with seed-feeding insects and two had significant numbers of weed seeds. Two habitat mixes attracted high numbers of night-flying pest moths. Two of the six mixes consistently attracted beneficial insects that are useful to agricultural pest management. These results provided a way for organic growers to identify quality habitats. Ongoing studies are focusing on which habitat mixes improve insect pest management in organic crops.
- c. Scope of impact – state and regional

Key Themes: Livestock Systems

Key Theme: Agricultural Competitiveness

- a. Issue: Soil and water loading of phosphorus from animal and poultry manures and litters is a major environmental concern. Potential restriction of land application of manure and litter could reduce livestock production and/or increase production costs. Either one threatens to reduce the economic viability and competitiveness of livestock and poultry producers and rural economies. Improving phosphorus utilization by livestock and poultry is one method to decrease the fecal output of phosphorus and its resulting land application and ensuring the competitiveness of livestock production.
- b. Impact: Degermed, dehulled corn (DDC) is produced by dry milling corn and results in the removal of 80% of the corn phytate P. Low-phytate soybean meal is a possible co-feed ingredient with degermed-dehulled corn. Low phytate soybean meal is produced from soybeans that have been genetically selected for reduced phytate content. Experiments were conducted to determine if feeding DDC to turkey poults would support growth performance as well or better than diets containing normal corn, and if such diets would reduce phosphorus (P) excretion from poults raised to 21 days of age. It was concluded that replacing normal corn with DDC resulted in improved growth performance in turkey poults. It was concluded that the use of low-phytate soybean meal resulted in bird performance equal to that of birds fed normal soybean meal while reducing fecal phosphorus. Thus, the development and use of degermed-dehulled corn as well as low-phytate soybean meal have the potential to benefit the U.S. poultry industry by increasing the sustainability of poultry production in many areas of the country.
- c. Scope of Impact - National

Key Theme: Agricultural Profitability

a. Issue: Modern strains of broilers produce much more heat during the latter stages of incubation and embryo development than did their predecessors of only 20 years ago. However, many of the more than 11 billion broiler hatching eggs produced annually in the U.S. are still being incubated in machines that were designed and/or built for the heat production of 20 years ago. The net result, in many instances, has been elevated embryonic temperatures during the latter stages of incubation. This has resulted in poor chick quality and reduction in broiler growth rate equal to as much as one day's growth or about 0.15 pounds from final live weight. Additionally, there has been evidence of increased mortality and poorer feed conversion as a result of high embryonic temperature. The basic mechanism for this reduction in performance appears to be delayed development of fundamental organs such as the heart and gastrointestinal tract.

b. Impact: A series of studies have been conducted to characterize the effects of elevated incubation temperature on embryonic development, specifically development of critical organ systems. This was followed by another series of studies that examined the effects of brooding temperature in broiler houses immediately following hatching on recovery of chicks from excessive embryonic temperature. The overheated embryo was much like a premature human infant in that it required additional "incubator time" after hatching. Therefore, a scheme was developed that exposed chicks to an elevated brooding temperature for the first 24 hours after hatching before resuming a normal brooding temperature profile. This was found to reduce significantly early chick mortality and improve overall performance. Of course, other work has focused on means to reduce embryonic temperature *per se* by altering incubator temperatures and ventilation. Overall hatchability, chick quality, and broiler performance have improved as a result. When fully implemented, altered incubational and brooding management of commercial broilers could result in the enhancement of performance, with a value of \$10 million annually for the NC broiler industry.

c. Scope of Impact - National

Key Theme: Animal Genomics

a. Issue: Application of marker-assisted selection for economically important traits of dairy cattle, such as disease resistance and fertility, would give U. S. dairy producers a greater rate of genetic improvement for these traits while continuing improvement in milk production. However, before marker-assisted selection can be implemented, DNA markers linked to the genes affecting these important traits or the genes themselves must first be identified and characterized.

b. Impact: Previous studies have shown that bovine chromosome 18 carries gene(s) affecting somatic cell score (an indirect measure of mastitis incidence), pregnancy rate, stillbirth and dystocia. Research to identify this gene or group of genes began this year. DNA markers were evaluated in a very popular U.S. Holstein bull and his descendants. Study of DNA markers in a large pedigree will improve our ability to refine the location of the gene(s). Preliminary results indicate the existence of at least one gene affecting pregnancy rate in this large Holstein family. Work is ongoing to further refine the location of the gene.

c. Scope of impact - National

Key Theme: Animal Health

a. Issue: Enteric diseases, of both bacterial and viral origins, are a major cause of economic loss within the North Carolina poultry industry each year. Bacterial infections have been typically prevented or treated through the prophylactic use of antibiotics. As consumer and regulatory pressures increase to stop the use of antibiotics in poultry feed, more and more producers are turning to probiotics or direct fed microbial products as a means of preventing and even curing enteric bacterial and viral infections. To date the assumption has been that the beneficial effect of probiotics is due to the competitive exclusion of pathogenic bacteria and viruses as well as stimulation of the host immune system. There has been little consideration within the scientific literature that other mechanisms of a beneficial nature may be involved.

b. Impact: Our laboratory has recently demonstrated that a dietary probiotic decreases the resting metabolic rate of broiler chicks. This reduction in resting energy expenditure is accompanied by increased growth. It is important to note that both of these effects, decreased metabolic energy expenditures and increased rates of growth, are larger in probiotic-fed broilers than in antibiotic-fed controls. Concomitant to these changes is an increase, by a 1.5 order of magnitude, in energy expenditure in the intestinal tract of the broiler chicks. Deductive reasoning tells us that because the positive effect on growth with the probiotic is larger than those noted with antibiotic feeding, and in spite of increased energy expenditures by the gut, other mechanisms must be involved other than stimulation of immune function or competitive exclusion of pathogenic bacteria and viruses. This program could serve as a conduit to the discovery of previously un-described mechanisms of growth enhancement for broilers and other species of poultry.

c. Scope of Impact - National

Key Theme: Animal Production Efficiency

a. Issue: Egg production by turkeys is among the poorest in domestic birds. It is about a third of that in chickens, so there is considerable room for improvement. The single most important factor limiting egg production in turkey hens is their development of a state of non-responsiveness (photorefractoriness) to the long day lengths that initially were used to induce the hens to lay eggs. If one can understand the nature and mechanisms of photorefractoriness, there may then be avenues for practical intervention with a resultant persistence of photosensitivity and prolonged production of eggs.

b. Impact: Until recently the only known method of terminating photorefractoriness and allowing turkey hens to lay eggs was to expose them to short day lengths for an appropriate period of time. However, recent identification of a neural locus for photorefractoriness in the tuberal neurons of the hypothalamus was a big step forward in understanding mechanisms. Recent advances in the neural locus of photorefractoriness, hormonal changes associated with photorefractoriness, and lighting effects on photorefractoriness have moved us closer to an understanding of photorefractoriness and its eventual control. With our current level of understanding, we can now terminate photorefractoriness pharmacologically for the first time. This potentially provides an additional management tool for controlling when, and for how long, turkeys will lay eggs.

c. Scope of Impact - National

Key Theme: Adding Value to New and Old Agricultural Products

- a. Issue: Feathers are a major by-product of the poultry industry, and they are generated at a rate of approximately one million tons per year. With their 90% protein content, it is important to develop a proper process to reclaim the difficult to digest keratin protein content of feathers in a much more digestible form.
- b. Impact: Over the past 15 years, NCARS research discovered and developed a feather-degrading keratinase enzyme that can now be produced in industrial-scale quantities. A series of research and commercial field experiments using keratinase as a feed additive have shown that it is effective in improving the digestibility of the proteins in feedstuffs, and growth to market age. In addition, in collaboration with researchers in the Netherlands, conditions for the degradation by keratinase of the BSE prion protein in the carcass of infected animals have been determined. Use by the broiler industry of keratinase will save \$6-\$10 per ton of broiler feed by allowing a significant reduction in crude protein in the diet to achieve the same performance. Given the 8 billion plus broilers produced each year in the U.S., the total feed cost savings in the U.S. could range somewhere between \$240-\$400 million.
- c. Scope of Impact - State specific

Key Theme: Animal Production Efficiency

- a. Issue: The environmental impact of mineral emissions from concentrated poultry operations must be reduced by improving dietary nutrient utilization and utilizing animal by-products as added-value nutrient resources.
- b. Impact: Through the use of lactic acid fermentation and extrusion processing, poultry protein by-products were converted into protein meals for fish, swine, and poultry that are about 15% more digestible than protein meals produced by conventional rendering methods. Secondary protein nutrients removed from poultry processing wastewater by air floatation, heat processing and centrifugation was found to be a valuable protein source for ruminants, while the oxidized fat fraction could be used as a combustible fuel.
- c. Scope of Impact: National

Key Theme: Aquaculture

- a. Issue: Commercial culture of hybrid striped bass is a relatively new agribusiness in North Carolina. The state has approximately 760 acres in production with 19 farmers, most with less than 10 years of fish farming experience. Despite efforts by area aquaculture agents and university researchers, production efficiency is still low. Feed costs, in particular, account for 40-50% of the operating costs. Average feed conversion efficiencies for other cultured fish are significantly better than that of hybrid striped bass
- b. Impact: Through a series of tank and pond trials, we have clearly demonstrated and quantified compensatory growth in hybrid striped bass. Feed conversion efficiencies have been improved by 30-40% with only slightly lower overall growth. These improvements have been achieved by

optimizing the periods of feed restriction followed by periods of satiate feeding. We anticipate that the overall reduced nutrient load entering the water column will lead to fewer water quality problems and eventually to reduced nutrients in effluents. In addition, improving the feed management of hybrid striped bass ponds in North Carolina, through simple changes in current practices, may bring substantial benefits to the industry. For instance, increasing the feed conversion efficiency by 30% through the timing and frequency of feeding has the potential to improve net profits by 12-15% for each producer.

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. Because their range of distribution extends from North Carolina along the Atlantic and Gulf coast into Mexico, the potential exists for culture in a large geographic area.

b. Impact: NCSU aquaculturists have succeeded in the production of commercial-scale quantities of weaned fingerlings and are completing the grow-out trials in re-circulating systems at different salinities. This research has established the importance of all-female stocks and underlined the research efforts directed toward gynogen production. Significant strides have been made in domesticating southern flounder and establishing this species as a new, high-value aquaculture species. This represents the first introduction of a fish with a worldwide market appeal and the capability of being cultured over a large geographic area.

c. Scope of Impact - Regional

Key Theme: Bioterrorism

a. Issue: There is a need for the national homeland security effort to focus on monitoring for the presence and dispersal of disease agents associated with poultry and livestock.

b. Impact: NCSU entomologists have been instrumental in the incrimination of filth flies in the dispersal of food borne pathogens between animal and human habitations and the transmission of viral diseases of livestock and poultry. Innovative methods have been implemented for the sampling of filth fly populations for the purpose of monitoring disease agents that threaten the biosecurity of food producing animals. Collaborations have formed to develop a microarray to detect and diagnose viral disease strains and their variants. Application of this technology could minimize the negative impacts on human and animal health, and lessen the economic impact of a disease outbreak.

c. Scope of Impact - National

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

Food and Fiber Processing, Safety and Quality

Overview

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

- Standardized sensory languages have been developed for application with cheese and dry milk/whey dairy ingredients. Instrumental and sensory techniques to link specific chemical compounds with flavor have been developed. The value of these tools and findings to the dairy industry has been estimated at more than \$1 million per year.
- A new method of recovering and refining edible meat from trimmings and deboned carcasses of meat, poultry, and fish removes the fat, connective tissues and bone. A method of solubilizing and injecting this meat protein into intact fillets and cuts of meats, poultry and seafood was developed. These technologies enhance the texture and taste of meat, poultry, and fish products. The new meat recovery method also reduces treatable effluent from meat processing factories.
- 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.

- 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 some of them in pursuing this technology.
- The price of U.S. peanuts in the world market is high compared to other export origins, and information was needed to indicate the high quality of U.S. peanuts. Major studies to determine composition, descriptive sensory and U.S. and European consumer preferences of peanuts from major origins have proven the superior quality and preference for U.S. peanuts and provided exceptional information for export marketing of U.S. peanuts.
- 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:

- 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.
- NCSU researchers along with researchers from three other universities and the United States Poultry and Egg Export Council (USAPEEC) developed a method for radionuclide testing of poultry for Russian export. NCSU laboratories currently perform radionuclide testing for approximately 25 large poultry processors exporting 200 million pounds of poultry annually.

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

- 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
\$ 324,784.08	\$ 2,287,388.15	\$ 542,213.84	\$ 544,057.10	12.61	46.21	25.43	1.23

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.

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

Key Theme: Food Quality

a. Issue: A process for manufacturing a modified-protein ingredient was patented and licensed by N.C. State University. This ingredient can potentially replace carbohydrate-based thickeners in food formulations. This is highly desirable with the low-carb trends. However, the cost of the protein ingredient is not competitive with carbohydrate products. Therefore, it is difficult to promote applications for the more expensive, protein ingredient.

b. Impact: Recently, a disclosure was filed that outlines a process to conjugate the modified protein with carbohydrates. The new ingredient couples an affordable starch product with the modified proteins, essentially extending the amount of protein. On an equivalent weight basis with the original modified protein, the new protein complexes display improved functionality with a third less protein. By conjugating carbohydrate to the modified protein, the functionality of the new ingredient is enhanced while lowering its cost, making the ingredient more economically friendly for product development.

c. Scope of Impact - National

Key Theme: Food Quality

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 cost 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. Standardized sensory languages have been developed for application with cheese and dry milk/whey dairy ingredients. Instrumental and sensory techniques to link specific chemical compounds with flavor have been developed.

b. Impact: NCSU researchers have developed quantifiable and validated sensory languages for dairy products. The value of these tools and findings to the dairy industry have been estimated at more than \$1 million per year.

c. Scope of Impact – National

Key Theme: Food Quality

a. Issue: NCSU extension specialists have established an entrepreneurial assistance program for value-added seafood products. So far, four individuals and 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 and 12 trout stuffings.

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 will be able to add additional revenues to their bottom line.

c. Scope of Impact – North Carolina and National

Key Theme: Food Quality

a. Issue: Foodborne disease is an important public health issue. The most significant foodborne pathogens from the standpoint of disease prevalence are the human enteric viruses (particularly the noroviruses), Salmonella, and Campylobacter. Currently, methods to detect pathogens in foods require growth of the organism in some sort of medium followed by detection, taking two or more days to achieve confirmed results. For viruses, which cannot grow in foods, detection is even more complicated. NCSU researchers have developed improved detection methods for pathogens including Listeria monocytogenes, Salmonella, Escherichia coli O157:H7, hepatitis A virus, and the noroviruses in ground beef, fresh produce, fermented dairy products, and various ready-to-eat products.

b. Impact: This improved method can detect at levels of 10^1 - 10^3 infectious units/10-25 g food sample.

c. Scope of Impact – National

Key Theme: Foodborne Pathogen Protection

a. Issue: Salmonella is an important enteric foodborne pathogen that has been closely associated with the consumption of contaminated poultry products. Salmonella Enteritidis, an egg-associated foodborne pathogen, has been shown to contaminate the interior of intact shell eggs via a transovarian route of infection that occurs in the hen's oviduct during egg formation prior to formation of the shell. Several factors may contribute to this contamination risk, including increased stress caused by feed and caloric restriction practices used by producers to induce feather molting for improving and sustaining egg production in older hens. A study by NC State University researchers showed that caloric restriction molting practices did not increase the incidence or shedding of Salmonella into the feces. In contrast, this study established that the initiation of the egg production cycle as well as the peak egg production period might contribute more to Salmonella fecal contamination than feed or caloric restriction. Moreover, elevated ammonia levels observed during peak egg production may contribute to bird stress and higher Salmonella fecal populations and incidence.

b. Impact: The egg laying industry will be able to dispel concerns that molting practices increase the incidence of Salmonella in eggs and thus foodborne illness.

c. Scope of Impact – National

Key Theme: Foodborne Pathogen Protection

a. Issue: The growth of animal agriculture has provided significant economic benefit to rural communities; however, perceived problems involving waste management practices spreading bacterial, viral, and parasitic pathogens and the consequence of using antibiotic-based growth promotants on increasing antibiotic resistance among human foodborne pathogens are a concern. N.C. State University researchers conducted a study on Salmonella litter and fecal populations and found their prevalence on commercial broiler farms were not statistically impacted by individual farm, season, or flock age. However, higher Salmonella populations were generally found during the winter and in older birds nearing market age. Moreover, a total of four different Salmonella serotypes were isolated from the six broiler houses, with Salmonella Kentucky and Salmonella Heidelberg being the two most prominent. Both serotypes, especially Heidelberg, have been previously associated with documented human foodborne disease outbreaks. Ninety-six percent, 83%, 78%, 39%, 26%, and 17% of the Salmonella isolates were resistant to at least 1, 2, 3, 4, 5, 6 or more antibiotics, respectively. However, none of the isolates were resistant to ciprofloxacin, the antibiotic of greatest concern by human health officials.

b. Impact: This study documented that the incidence of Salmonella in commercial broilers was greatest during winter in older bird populations. Also, 96% of Salmonella isolates were resistant to at least one antibiotic, and 17% were resistant to at least six.

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

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; and developing methods for mitigating impacts of insects and related arthropods as vectors of human and animal diseases, as direct pests of humans and their domestic animals and livestock, and as pests of human habitations and institutional buildings.

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

- A radiant frying process (patent pending) whereby frying can occur without oil has been developed. This new technology can reduce oil content in fried fast foods from 20 to 50% without altering taste or texture.
- Through selected heat processing technologies, the antioxidant content of many berry juices has been maintained while retaining flavor and juice quality. Blended juices show superior quality and antioxidant content compared to commercial juices.

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

- The mechanism has been uncovered by which environmental stress induces cell death. This will contribute to develop better treatment for cellular stress-related disease.
- 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.
- Research found that the cellular iron-storage protein ferritin protects cells from some environmental chemicals that produce oxygen free radicals, leading to cancer, Parkinson's disease, Alzheimer disease, heart disease and aging.
- 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*.
- Several novel genes that are expressed in the midline cells of the central nervous system during *Drosophila* development have been identified. An understanding of the development of the central nervous system is required for the development of new ideas and techniques for treating neuronal birth defects and lesions, but this work will also contribute to our knowledge of basic processes of gene expression, cell signaling, cell connectivity and signal transduction.

- 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.
- The isolation, biochemical characterization and structural analysis of *P. furiosus* prolidase have provided valuable information regarding the potential use of this enzyme to degrade toxic organophosphorus nerve agents such as soman and sarin. Ultimately, the biochemical and structural data can be used to modify *P. furiosus* prolidase to improve its activity and stability for use in organophosphorus nerve agent detoxification.
- Modified vaccinia Ankara virus (MVA) is a highly attenuated virus that is being evaluated as a replacement for the current smallpox vaccine, as well as for other applications in antiviral prophylaxis and anti-cancer therapy. We are developing new approaches for the genetic analysis of MVA to provide important information for the further development of MVA.
- 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 (levonorgestrel, 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.
- Statistical methods for analyzing protein sequence data when the protein structure is known and assumed fixed over time have been developed. The important feature of these new statistical methods is that dependence among positions in a protein structure where this dependence stems from constraints on protein sequence evolution that serve to maintain protein structure can now be incorporated.
- Vitamin B₆ is an essential vitamin for all living organisms. Until recently, little was known about how this essential vitamin was synthesized in cells of organisms other than bacteria. The pathway genes that are responsible for synthesis of vitamin B₆ in tobacco and Arabidopsis have been identified. Understanding how plants synthesize vitamin B₆ will allow for the engineering of crops with enhanced nutritional composition.

- A protein called cPLA₂, which is central to the inflammatory process, has been identified. Regulatory signals involved in activating this enzyme and beginning the inflammatory response are being studied. The results of this project have the potential to impact the health and well being of society by providing the foundation for the development of therapeutic strategies to combat inflammation.

Performance goal 3, which attempts to develop methods for mitigating impacts of insects and related arthropods as vectors of human and animal diseases, as direct pests of humans and their domestic animals and livestock, and as pests of human habitations and institutional buildings, has been focused on by the following research:

- 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.
- Exposure to cockroach allergen is the most important risk factor for asthma in inner-city households. Intervention studies by NCSU entomologists in homes have documented that clinically relevant reductions in exposure to cockroach allergen can be achieved with combined efforts involving occupant education, placement of insecticide bait, and cleaning.
- 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.
- Studies supporting the national homeland security effort focus on monitoring for the presence and dispersal of disease agents associated with poultry and livestock. Veterinary entomology has been instrumental in the incrimination of filth flies in the dispersal of food borne pathogens between animal and human habitations and the transmission of viral diseases of livestock and poultry. Innovative methods have been implemented for the sampling of filth fly populations for the purpose of monitoring disease agents that threaten the biosecurity of food producing animals.
- The Formosan subterranean termite is a destructive invasive species that has become established in many parts of the southern U.S. and Hawaii. NCSU entomologists are using molecular genetic markers to retrace the origin and spread of this pest in the U.S. This work will help in targeting likely routes of spread of this species to help prevent future introductions of this and similar destructive termite pests.
- A socio-economic study of La Crosse encephalitis was completed. The socioeconomic burden resulting from this disease is substantial and highlights the importance of the illness in disease endemic areas of North Carolina as well as the need for active surveillance and prevention programs for the vector/virus complex.
- 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
\$186,652.42	\$2,387,388.15	\$574,389.45	\$584,966.12	8.51	22.90	15.60	2.86

Key Theme: Human Health

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

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

c. Scope of Impact – State Specific

Key Theme: Human Health

a. Issue: Because ovarian cancer is difficult to detect, it is generally diagnosed in advanced stages, and only 35% of ovarian cancer patients are cured. With 16,000 to 17,000 women dying in the U.S. from this disease annually, screening chemo-preventive compounds more rapidly would result in more lives saved. 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: The protein named Ras is a small GTPase involved in the control of cell proliferation in humans, and most all organisms. Several of the mutant forms of Ras have been directly linked to human cancers, as these mutant forms of the protein remain in an activated state of cell proliferation that leads to uncontrolled cell division. Ras is a member of a group of structurally similar proteins, all of which are involved in highly specific cellular interactions with regulatory agents that control their ability to bind to target proteins within complicated signal transduction cascades within the cells.

b. Impact: Scientists have done the necessary molecular biology procedures to express amounts of particular Ras proteins of interest to be used in crystallography studies to collect and analyze data on the structure of each protein. With an understanding of these structure interactions and the rules by which they operate, it may be possible for some form of drug intervention to be developed to treat cancers caused by these mutant Ras proteins.

c. Scope of Impact - National

Key Theme: Human Health

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

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

c. Scope of Impact - National

Key Theme: Human Health

a. Issue: Traces of the evolutionary process in malaria lie in the information found within as well as between species. These traces allow us to make genome-wide historical inferences of mutation, recombination and inbreeding, which, in turn, can be used to map portions of the genome under natural or artificial selection. Identifying genomic regions that allow *P. falciparum* to adapt to new environments 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*. For association or mapping studies to be effective, the above information is critical. In collaboration with Xin-zhuan researchers at the National Institute of Allergies and Infectious Disease (NIH-NIAID), and at Oxford, N.C. State University researchers developed and tested evolutionary models that shape genome-wide *Plasmodium* haplotype variation – the Malaria HapMap. By combining computational approaches with the emergence of genome databases and new population genomic data, researchers used theoretical and experimental approaches to investigate areas of central importance to mapping genes under selection.

b. Impact: The high mortality rate associated with *Plasmodium* infection—an estimated 1.1–2.7 million people die each year from malaria—leads to strong selection both on host genes that contribute to resistance and on parasite genes involved in the infection process. The complexities of recombination and mutation properties in *Plasmodium* impact the design of studies to determine genes affecting resistance to immunity for this and other organisms. However, this research supports the feasibility of genome-wide association studies in some parasite populations.

c. Scope of Impact - National and International

Key Theme: Human Health

a. Issue: Complex, or quantitative, traits are affected by multiple interacting genes that are sensitive to the environment. Most characters that are important for human health (for example, susceptibility to heart disease, cancer, or diabetes); agriculture (production and yield traits); and adaptation of populations to their environments are complex traits. A major challenge is to determine what are the genes affecting complex genotypes, as genetic methods of analysis developed for single genes with large effects are not appropriate. The use of model genetic systems, such as the fruit fly, *Drosophila melanogaster*, enables quick and efficient testing of new methods of analysis. The principle of conservation of genes affecting all fundamental biological processes means the genes affecting genetic variation of a trait in flies are likely also to be important for similar traits in humans and other organisms (for example, lifespan).

b. Impact: Quantitative trait loci have been mapped by linkage to molecular marker loci in pedigreed populations. The complexities of quantitative variation in *Drosophila* impact the design of studies to determine genes affecting quantitative traits in humans and other organisms. It has been proposed that such genes can be mapped by genotyping a random sample of individuals for single nucleotide polymorphisms ('SNPs') in protein coding regions of candidate genes, and associating the genotype with disease or other trait status. The work with fruit flies has shown that this strategy is likely to fail unless (1) the density of SNP markers is much greater than has been proposed, (2) markers are included in non-protein coding (regulatory) regions, (3) larger sample sizes are used, and (4) the

effect of sex and other demographic factors are included. A potential future impact of this research is the identification of genes conferring postponed senescence.

c. Scope of Impact - National and International

Key Theme: Human Health

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.

Impact: A molecule identified as important for autoimmune disease could be used as a target for pharmaceutical development. The vaccine developed could be used by swine producers to reduce the impact of PRRS on their herds.

c. Scope of Impact - National and International

Key Theme: Human Health

a. Issue: RNase P is an ideal potential target for new antimicrobials; it is very highly conserved in structure in bacteria, and yet is very different in eukaryotes (including humans). Interfering with an essential and highly conserved structure in bacterial RNase P should be effective against a swath of bacterial pathogens. It also appears that variation in RNase P is greater in eukaryotes than in bacteria, so it may also be possible to design or discover drugs targeting RNase P that are effective against eukaryotic parasites. This will require a much better understanding of the structure and evolutionary variation in this enzyme, insight that is best provided by an understanding of the simpler and more primitive relatives of eukaryotes, the Archaea, because the eukaryotic enzymes have been resistant to study. Research is focused on determining the composition of RNase P in Archaea, solving the structure of each of these subunits, assessing how each of these subunits contribute to the function of the enzyme, and comparing the evolutionary variability of each of these aspects of the enzymes from bacteria and eukaryotes.

b. Impact: This work has resulted in a burst of research worldwide on the archaeal RNase P, including efforts by physical biochemists to solve the three-dimensional structures of the proteins and RNAs, and a report of the successful reconstruction of the human RNase P, based on identification of the most conserved subunits. These results have implications for the RNA World hypothesis and theories about the relationships between various ribonucleoproteins (including the ribosome). This 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*.

c. Scope of Impact - National and International

Key Theme: Human Health

a. Issue: Numerous genes within any metazoan genome are involved in directing development of the adult body from a single-celled fertilized egg. Mutations in these genes are known to cause birth defects in humans and other animals. Further, non-genetic sources, for instance natural or non-natural substances in the environment, prescription drug interactions or even substance abuse, can lead to defects in developing animals. The cost to society is very high (through care and treatment of humans with birth defects or in lost yield in animal and plant breeding programs). The more we understand about how the genes control development, the better we will be able to address health and agricultural issues.

b. Impact: The costs in medical expenses and lost yield due to defects in embryonic development are quite high. It is estimated that the cost due to birth defects from alcohol abuse alone is over \$2 billion. However, the social cost, such as quality of life and hardship, cannot be estimated, and it is difficult to estimate the loss to agribusinesses. With a better understanding of the developmental process, we may be better able to predict and identify agents that can adversely affect development. Since studies have shown that some environmental factors can alter Hox-C/hox gene expressions, and thereby cause developmental defects, understanding how these proteins regulate development will help us understand and perhaps prevent these defects.

c. Scope of Impact - National and International

Key Theme: Human Health

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

b. Impact: A novel system for dissecting the molecular mechanisms underlying differential gene segment recombination has been developed. This system includes separate B and T lymphocyte cell lines which will express recombinase proteins upon alteration of culture conditions, generation of a novel DNA recombination substrate, isolation of the mouse D β 2 transcriptional promoter, and development of chromatin immunoprecipitation assays that allow us to measure recombinase protein binding at individual gene segments. The inability to complete recombination impairs lymphocyte development, leading to immunodeficiencies of varying severity. Conversely, inappropriate targeting of recombination can result in chromosomal translocations that lead to lymphoid malignancies. This research will provide a molecular framework for understanding the strict ordering of antigen receptor gene assembly. Given the involvement of multiple transcription control elements in V(D)J recombination, the proposed studies additionally promise more global insights into the general developmental mechanisms that underlie tissue-specific gene activation.

c. Scope of Impact - National and International

National Goal 4: 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.

- Engineers developed a protocol for the verification of technologies for separation of manure solids from flushed swine waste under an arrangement with the Water Quality Protection Center operated by NSF International in conjunction with the EPA's Environmental Technology Verification Program.
- Soil scientists determined that heavy metal contaminants at sites associated with the Marine Corps Air Station at Cherry Point, NC posed no significant environmental threat. Regulators decided that “No further action” was required at these sites, which avoided taxpayer costs estimated at more than \$150,000 for further investigations and long-term monitoring.
- Investigations are being conducted on the fossil plants found in Early Campanian (ca. 80 million years ago) sediments in North Carolina. These studies are providing a comprehensive picture of the plant taxonomy and ecology of these past environments and are leading to a defining of the history of North Carolina's flora. This work provides us with a greater understanding of the changes that have happened in Earth's history, as well as the effects of these changes.
- An important mechanism controlling the bioavailability of aromatic hydrocarbons has been discovered that will lead to more accurate human health and ecological risk assessments.
- The computer model VFSSMOD enables water quality regulators to size vegetative buffers and evaluate their effectiveness reducing sediment transport to surface waters over a range of soil types. Over the past year, the windows-based model has been downloaded from the internet by more than 100 users from all over the world.

- Savannas and evergreen forests are the two most important tropical vegetation types in terms of area, biodiversity, and economic use. The effects of humans on the transition between these types override the changes driven by natural factors, and have consequences for biodiversity conservation, climate change, and sustainability of current land uses. Differences between savanna and forest trees that have major consequences for savanna-forest dynamics and ecosystem properties are being characterized. This work will allow for the construction of models to better predict climate changes as well as the effects of anthropogenic disturbance on our ecosystem.
- Results of drainage intensity work point out the need for additional studies on its effect on N loss from drained fields. Our past work in this area has been at least partially responsible for the initiation of research in Illinois and Minnesota to determine effects of drain depth and spacing on N losses to surface waters.
- Research on turf grass and managed, waste-receiving grasslands has shown that the soil is a significant sink for nitrogen fertilizer, which refutes a commonly held idea that old turf grass systems or waste-receiving grasslands are environmentally unsafe.
- Restoration of prior converted croplands to conditions that meet the hydrologic, soil, and vegetation criteria that define jurisdictional wetlands, improves water quality and provides wildlife habitat.
- The Carolinas support a one of the most diverse natural communities in the US. Faculty, staff, and students from CALS and CNR have participated since 1987 in a regional consortium known as the Carolina Vegetation Survey (CVS), which establishes and inventories permanent plots placed in representative natural areas. The information collected since 1988 represents one of the richest databases of its kind in the United States. Conservation, appropriate use, and appreciation of this valuable natural resource are dependent on comprehensive and quantitative inventory, description, and classification of these communities.
- Research has shown that several of the most frequently used herbicides and insecticides on North Carolina crops are not acutely toxic to the early life stages of native freshwater mussels, assisting natural resource managers and regulators in environmental decision making.
- Observations on a sandy soil coupled with tracer chemicals movement data for a large sand column show that the saturated zone immediately above the water table plays an important role in the retention and transport of chemicals in soils. If these observations hold true, and chemicals remain and move laterally within the capillary fringe, different strategies must be employed for collecting ground water samples for assessing fate of pollutants in the environment.
- Quantification of specific gaseous and particulate 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.
- Modern large-scale animal production facilities represent sources of potential pollutants that can negatively impact environmental and human health. Current research employs state-of-the-art scientific techniques to assess reductions in ammonia emissions from proposed alternative Environmentally Superior Technologies for swine production. This information, combined with data on reductions in pathogen and odor emissions, will contribute to an evaluation/ranking of the 18 proposed. Environmentally Superior Technologies for swine production in North Carolina.

- The Center for Applied Aquatic Ecology is dedicated to understanding and improving the ecology of freshwater, estuarine, and marine ecosystems in North Carolina. The Center addresses applied issues spanning from enhancement and protection of fish nursery habitats to human health impacts from *Pfiesteria* to impacts of algal blooms on aquatic food webs. The research results provided the framework that was used by the U.S. Congress and federal agencies to direct more than \$600 million to control pollution in estuaries and coastal waters in many states.
- Key components in the regulatory pathways that control sexual development in invertebrates have been discovered. This information will be of use in the development of new insecticides and in protecting economically important invertebrate resources (i.e., crabs, shrimp, etc.).
- Soil scientists developed a method for analyzing phosphorus associated with each of the two most important types of soil minerals that inhibit phosphorus movement from agricultural lands to streams, rivers, lakes, and estuaries. This work provided an understanding of soil phosphorus that will help in developing better strategies for producers to manage phosphorus within USDA-mandated guidelines
- The dogwood family and relatives contain plant species that are both economically and ornamentally important (e.g., the dogwoods, hydrangea, and mock oranges), but are among the most poorly understood groups of flowering plants. Studies are being conducted on the evolutionary relationship of species and the pattern of geographic distribution. These studies are leading to an understanding the mechanisms of biological adaptation, speciation, and evolution in this group, and address issues essential for the study and preservation of the earth's biota.
- Returning prior converted cropland that is located adjacent to nutrient sensitive estuarine waters to wetland is expected to improve water quality and allow shellfish beds to be opened to harvesting.
- Conservation of federal and state rare plant species is required by federal and state legislation. Studies of two federally-listed species and a state-listed species have led to the understanding of factors influencing seed production, transplant survivorship, pollinators, and competition with other species. These studies have provided specific conservation recommendations for the NC DOT and the US Forest Service.

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
\$441,192.80	\$2,684,200.70	\$1,245,113.40	\$1,032,844.70	12.86	16.04	22.84	3.34

Key Theme: Water Quality

a. Issue: Published field data from Indiana and North Carolina were plotted as a function of drainage intensity, DI, which was defined as the steady state drainage rate when the water table at a point midway between the drains is coincident with the surface. Trends for NO₃-N loss as a function of DI were similar for soils in the two states in spite of large differences in weather and soil conditions. These data indicated that the magnitude of NO₃-N loss in drainage waters is strongly dependent on DI. Simulations were conducted to examine effects of drain depth, spacing and soil properties on processes that affect NO₃-N loss from drained soils. The use of DI explained or normalized the effect of these variables on some of the processes but not others. Results showed that, in addition to its affect on DI, drain depth appears to have a significant impact on NO₃-N losses.

b. Impact: Results of this work point out the need for additional studies on the effect of drainage intensity on N loss from drained fields. Our past work in this area has been at least partially responsible for the initiation of research in Illinois and Minnesota to determine effects of drain depth and spacing on N losses to surface waters. This work will assist researchers in quantifying the losses in terms of the more general concept of drainage intensity, rather than design parameters, which are soil and site specific. The work will also focus attention on the need for research to understand the mechanisms that cause reduction of N losses with reduction in drainage intensity.

c. Scope of Impact - State Specific

Key Theme: Air Quality

a. Issue: A low-cost regenerating scrubber is being developed that can be used to reduce or eliminate aerial pollutants from animal houses. In the wet mode, the scrubber is designed to reduce gaseous emissions while in the dry mode, it is designed to reduce particulate as well as gases bound to particulates. Upon completion of the scrubber fabrication, it will be evaluated in both the wet (swine) and dry (poultry on litter) modes.

b. Impact: The scrubber may be a useful tool in a toolbox of technologies and practices that swine and poultry producers would have at their disposal to reduce gaseous and particulate emissions from their operations. If found to be effective, the scrubber may find wider acceptance not only because of its low cost but also because it could be used to retrofit existing animal feeding operations.

c. Scope of Impact - State Specific

Key Theme: Soil Erosion

a. Issue: Researchers at North Carolina State University, with NCARS and USDA support, have continued development and support of engineering design tools to help water quality specialists size vegetative buffers to reduce off-site movement of eroded soil. The computer model, VFSSMOD, simulates the effectiveness of vegetative filter strips to trap sediment. A graphical user interface along with tools to enable users to assess the uncertainty of the performance of the filter strip performance makes evaluating multiple designs based on ranges of storm sizes and filter strip lengths easy. Development of additional tools to make the model easier to apply and evaluate the results is continuing.

b. Impact: Erosion continues to be a major source of non-point pollution for North Carolina's surface waters. The computer model VFSMOD enables water quality regulators to size vegetative buffers and evaluate their effectiveness reducing sediment transport to surface waters over a range of soil types. The model and documentation is available via the internet. Over the past year, the windows-based model has been downloaded by more than 100 users from all over the world.

c. Scope of Impact - State Specific, Multistate Research (NC, FL)

Key Theme: Water Quality/Air Quality

a. Issue: An interdisciplinary research project on ammonia emission control for swine waste management has been conducted by the Biological and Agricultural Engineering and Civil, Construction and Environmental Engineering Departments of North Carolina State University. 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 (soluble chemical oxygen demand/nitrogen ratio was about 0.95). 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. Aeration created an aerobic environment for nitrification, while non-aeration provided an anoxic condition for denitrification. To optimize the IA process, different Aeration:Non-Aeration (ANA) ratios were used in the reactors as follows: 1 hour : 1 hour; 1 hour : 3 hours; 1 hour : 4 hours; 1 hour : 5 hour; 1 hour : 6 hours. The hydraulic retention time (HRT) and solid residence time (SRT) for the reactors were 3 and 20 days, respectively. Over 87% of total nitrogen and 90% of ammonia were removed from the wastewater in all reactors except the one with ANA ratio of 1 hour : 6 hours which failed. Based on biochemical stoichiometry, the influent did not contain enough soluble chemical oxygen demand for denitrification. However, the high nitrogen removal efficiency indicates that the required carbon must have been obtained from the solubilization of solids contained in the influent or from microbial decay byproducts. Oligonucleotide probes were used in quantitative membrane hybridizations to quantify populations of ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) in the reactors. It was found that *Nitrosomonas/Nitrosococcus mobilis* were the dominant AOB, while *Nitrospira*-like organisms were the dominant NOB. No significant difference was observed in AOB levels among the reactors.

b. Impact: The intermittent aeration technology investigated in this project would provide an efficient method to control ammonia emission and remove nitrogen from animal wastewater. The results from this project indicate that high ammonia and nitrogen removal can be achieved with the non-aeration time of as long as 5 hours in each cycle. Compared to continuous aeration, the operation of intermittent aeration with 1 hour aeration and 5 hour non-aeration in each cycle would reduce the energy cost for aeration by 4-5 fold. It is a significant reduction of the cost for the treatment system. Removal of ammonia from the wastewater would significantly reduce ammonia air pollution, improve air quality inside the animal houses for the health of the workers and the growth of the animals, and alleviate struvite clogging problems of pipes and pumps. The intermittent aeration technology for nitrogen removal from animal wastewater would benefit the animal production industry and our environment. In addition, in this project we have identified 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.

c. Scope of Impact - State Specific

Key Theme: Air Quality

a. Issue: A number of state-of-the-art techniques for measuring ammonia emissions from housing units and water-holding structures have been combined to assess the reduction in ammonia emissions possible when proposed environmentally superior technologies are deployed at swine production facilities. To date, over 15 technologies have been evaluated during two seasons of the year (summer and winter) and the resulting emissions incorporated into a strategy to allow differentiation of reduction in ammonia emissions as compared to a standard Lagoon and Spray System while still accounting for variables such as local and seasonal weather patterns and differences in animal populations and ages of animals. A series of reports have been provided to the Animal and Poultry Waste Management Center, NCSU, Raleigh, NC, which is charged by the North Carolina Attorney General's office to conduct the evaluations. This information will be combined with data regarding pathogen reduction, reductions in odor and odorants, and economic analyses to derive a basis for evaluation/ranking of the 18 proposed Environmentally Superior Technologies for swine production in North Carolina. All evaluations are to be completed and final report filed by July 1, 2005.

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

c. Scope of Impact - State Specific

Key Theme: Water Quality/Water Availability

a. Issue: North Carolina State University with support from the N.C. Ecological Enhancement Program, has evaluated techniques for restoring and creating wetlands. Research and monitoring indicate that restored wetlands, provide many of the functions and values of natural wetlands within a few years. Research in progress has the goal of quantitatively comparing functional attributes such as soil color, redox potential, nutrient concentrations, depth to water table, and plant growth in restored wetlands with natural reference sites.

b. Impact: Successful wetland restoration has positive environmental and economic benefits. It 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.

c. Scope of Impact - State Specific

Key Theme: Agricultural Waste Management

a. Issue: Eight potentially promising technologies were critically studied for their capability to meet environmental performance standards primarily targeting the swine industry as previously established by the NC General Assembly. The environmental variables included the impact of animal waste to surface waters and groundwater; emission of ammonia; emission of odor; release of disease-transmitting vectors and airborne pathogens; and nutrient and heavy metal contamination of soil and groundwater. Two of the technologies considered were shown to be capable of meeting these standards. Those technologies are: 1) a solids separation / nitrification–denitrification / soluble phosphorus removal system and 2) a high solids anaerobic digester system. The data also indicates that, with technical modifications and/or combination of other technology unit processes, additional technologies considered may meet the environmental performance criteria.

b. Impact: The Animal and Poultry Waste Management Center was established to address waste management issues, to find ways to ensure the vitality of the state’s important animal and poultry production industries, worth nearly \$4 billion annually, while also protecting the environment. Waste management technology development and performance evaluations, including economic feasibility determinations, such as the initiative described above will provide the industry and North Carolina policy makers and others with scientifically based information, which will allow them to make informed decisions that will affect the environment and an important segment of the state’s economy.

c. Scope of Impact - State Specific

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

Overview:

Major change in rural communities and rural life in North Carolina and many other areas of the country 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 thorough research on the part of the Land Grant system. Social and economic restructuring, the reorganization of agriculture and natural resource-based industries, de-industrialization and outsourcing, the shift to a service 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 events not under the control of North Carolina farmers, have contributed to further uncertainty and stress in rural communities. The tobacco buy-out has brought with it a new set of uncertainties and decisions for the rural South. Many research results described here have helped to mitigate some of the stresses on rural communities. Others have contributed to the development of strategies for improving the economic viability of rural communities. Still others have contributed to the welfare of Americans through research to create a better understanding of quality of life issues.

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

The following projects involved the globalization of food and manufacturing and the impact on rural communities.

- National Public Survey on the Globalization of Food - Earlier results from the S276 multi-state project's national survey of U.S. adults as released on the web and other media were welcomed and used by many farm organizations in their meetings, workshops, and media. The findings showed that Americans hold family farms in high regard and want food that is produced locally and under environmentally safe conditions but do trust food produced in foreign countries.
- ? Displaced Rural Workers - Interviews and focus groups investigate the consequences of job displacement on low wage workers in Robeson County North Carolina. Displaced workers followed a variety of paths after job loss including education and re-employment, marginal employment, informal work, retirement, and reliance on family-based networks. Policies for displaced workers need to adopt a client/case orientation and both public and private organizations need to expand outreach and increase capacity.

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.

The following projects involved analysis of agricultural policy-related issues.

- ? Study of the Hog-Corn Cycle - The hog industry remains as one of the most economically important agricultural sectors in North Carolina and beyond. In recent years the hog industry in the United States has undergone extensive institutional and technological changes. In recent years some have argued that these changes have effectively eliminated the hog-corn cycle. An important question then is: does a model that explicitly account for the institutional and technological changes that have occurred in the hog market over time, as well as important features of a perceived hog cycle, forecast better than a simpler model that does not allow for these potential aspects of the hog market to play a role? The model developed as a result of this research should allow for improved forecasts of future economic conditions in the hog-corn sectors in the U.S., and for that matter, possibly in North Carolina. The results show, for example, that, on average, when forecasting ahead between six and eighteen

months, that the non-linear model improves upon the forecasting performance of the linear model between 18 and 35 percent.

- ? Analysis of the Impacts of the Tobacco Buyout - During the legislative efforts to develop and pass a tobacco buyout, economic analysis of various options considered was provided to legislative offices and policy organizations. This included analyses of the impact of buyout payments on farmers, the agribusiness sector, and rural economies. The work also included analyses of potential programs regulating tobacco production after elimination of the federal tobacco program. In addition, analyses were provided on how the price, quantity, and location of U.S. tobacco might change with the elimination of the tobacco program. Since the buyout has become law, in-service training for cooperative extension agents has been conducted on the implications of the compensation provided in the tobacco buyout and the elimination of the tobacco program. Six regional workshops on the tobacco buyout legislation, its tax implications, whole farm business planning and decisions, and the economic outlook for tobacco were conducted for tobacco growers in eastern North Carolina and five were planned for the piedmont and mountains.

Youth and adolescent development were addressed by the following projects.

- Adolescent Development and Peer Relations - A team of faculty and graduate student are interviewing middle-school children to assess the effect of peer relations on self-esteem, academic orientation, and risk-taking behaviors. Analysis will focus particular attention how children understand their own lives, and identify if differences exist by economic privilege, gender, or race. Initial findings suggest that most children have adopted verbal rhetoric of equality, which complicates the lives of those who are disadvantaged in unexpected ways.
- Youth Workers - Nearly four million teenagers are employed in the United States. We identified a national sample, using targeted and random digit dialing methods, and conducted 20-minute interviews with 900 pairs of working teens and their parents. Results show that teen workers are performing numerous hazardous and illegal tasks, yet express little concern about safety. Teens lack knowledge of worker safety and child labor laws.

Rural infrastructure was the topic of the following projects.

Public Road Crashes of Farm Vehicles - Although farm vehicle public road crashes are a relatively rare event according to official highway statistics, they are of particular concern to farmers. A case-control study design was used to compare North Carolina farms reporting a farm vehicle public road crash (1992-2003) with farms that had not experienced one. Results show that driver, vehicle, farm, and environmental characteristics increase the likelihood of farm vehicle public road crash group membership and that increased attention needs to be given to safety training for hired help and non-English speaking help who drive farm vehicles on public roads.

- Economic Impacts of Large Residential Developments - Research assessed these costs and benefits of the overall economic impact on a county of a proposed, large residential development. The particular case of Briar Chapel, a very large residential development under consideration by the Board of Commissioners in Chatham County was studied. This research led to the following conclusions.
 - Briar Chapel will undoubtedly increase economic activity within Chatham County, in the form of new home construction and retail purchases by new residents. The size of this increased economic activity will be substantially smaller than has been

projected by the project’s developers, largely because so many workers within Chatham County actually reside outside of the county, and because a substantial fraction of retail purchases by Chathamites occur in other nearby counties.

- The employment created as a result of Briar Chapel will generally be low paying, service sector jobs. There is substantial uncertainty as to whether or not Briar Chapel will pay for itself in terms of county government finances.
- Briar Chapel will have a negative effect the quality of life for some current Chatham County residents, in large part due to huge increases in traffic along the main highway corridor connecting the county with nearby Durham and Chapel Hill.
- The amenities of Briar Chapel will primarily benefit new residents, whereas the costs imposed by the dis-amenities of Briar Chapel will be felt by a relatively large number of current residents.

In the final analysis, the Briar Chapel development represents a mixture of good news for some and bad news for others. Such a mixture of positive and negative impacts is common for many large-scale economic “shocks.” Other counties in which similarly large residential development projects are currently being proposed stand to benefit from careful, objective analysis of these positives and negatives.

The effect of environmental policy on older adults was the topic of the following project.

- Older Adults’ Valuation of Mortality Risk Reductions - Reductions in premature mortality account for 90% of the estimated benefits due to implementing regulations defined by the 1990 Clean Air Act Amendments. In 2003 the U.S. Environmental Protection Agency in analyzing the Clear Skies regulatory initiative included a “senior discount” – an adjustment in the estimate used to measure an individual’s willingness to pay for a small reduction in mortality risk based on age. Individuals over age 70 were assumed to have a willingness to pay that was 63 percent of those under 70 on the grounds that, on average, they had a shorter remaining lifetime. This research with collaborators has demonstrated that actual labor market choices of older adults are not consistent with these assumptions. In fact, their willingness to pay for small reductions in mortality risk may be larger than that estimated for younger adults. Higher incomes and wealth, greater risk aversion, along with recognizing that there may be less time left for them, are all consistent with these estimates.

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
\$105,680.00	\$1,170,525.00	\$54,856.50	\$7,579.60	6.39	11.34	1.5	1.51

Key Theme: Supplemental Income Strategies

a. Issue: Fruit and vegetable growers have always faced dynamic, rapidly changing markets. Economic pressure has resulted in dramatic structural changes throughout Southern agriculture. Currently, the pressure is to move toward offering value-added products. The question is whether or not barriers exist to prevent successful movement in that direction.

b. Impact: The research found that for decades, many growers in all four states grew a similar mix of livestock and crops and a number of producers derived their primary source of income from tobacco. Over time the mix of commodities has changed dramatically. Kentucky agriculture now derives a majority of its gross farm receipts from the sale of horses, broilers, and cattle while Tennessee growers obtain one-third of their total gross farm receipts from beef cattle and broilers. In North Carolina, tobacco receipts remain important but account for less than 10% of gross farm receipts as growers have moved into hog, broiler, and greenhouse–nursery production. These results indicate that the surveyed states have begun to make the change to more value-added products, but that some are farther along than others.

c. Scope of Impact - Region Specific

Key Theme: Jobs/Employment

a. Issue: North Carolina's economy is undergoing tremendous change, and perhaps no other sector has changed more than agriculture. Agriculture output and productivity have soared while employment has fallen. Yet most citizens measure the value of an economic sector by its number of workers, and therefore many have concluded that agriculture contributes little to the state economy. This project annually measures the contribution of agriculture and agribusiness to the state economy. Similar measures for each of North Carolina's 100 counties have also been developed. These statistics show a very large contribution from agriculture and agribusiness to the state and county economies.

b. Impact: The statistics have been published in various forums and using various media outlets. They are now commonly used by university and state officials. The statistics have established the large economic impact of agriculture and agribusiness to the state economy.

c. Scope of Impact – State Specific

Key Theme: Consumer Management

a. Issue: There has been a rising spread between retail and farm prices for food and the farmer's portion of the total food dollar has declined over time. Many point to this fact as one of the causes of a general decline in rural communities.

b. Impact: Policymakers have been divided over what the cause of increased food price margins for food has been. Some have called for further regulation of food industries, including such things as reducing the level of vertical integration of agriculture both upstream in production and downstream in wholesaling and retailing. These results indicate that the cause of the increase has instead been consumers demand for more value added to existing goods and that regulation may actually stifle growth in the food industry and therefore make farmers worse off.

c. Scope of Impact - National

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

North Carolina State University faculty were involved in 26 Multistate Research Projects in the Southern Region, 41 Multistate Research Projects in other regions, and 14 Southern Extension and Research Activities. These activities were all multistate, multidisciplinary and involved integration of research and extension. They continue to be an excellent vehicle for collaborative, coordinated research and a broad-based, systematic approach to solving problems relative to the Southern Region and the nation. The impacts of these projects are indicated in the respective Goal reports as well as the in the Integrated reports. Some examples of multistate, multidisciplinary, integrated activities other than those included above are discussed below.

The National Center for Manure and Animal Waste Management

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

part of 2004 discussions took place that resulted in strategic directions to combine the National Center for Manure and Animal Waste Management and the NCSU Animal and Poultry Waste Management Center into one national center to be housed at NCSU. Discussions continue on the strategic plan and financing plan to achieve that union.

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

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

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

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

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

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

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

Southern Region Small Fruit Consortium

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

Twelve research grants totaling \$56,600 and three Extension grants totaling \$10,000 were awarded in 2004 to faculty in the four member states. An additional \$9000 was leveraged from the IR-4 Performance program to match two of the research grants dealing with pesticide evaluations.

Research Sponsored by the Southern Region Small Fruit Consortium in 2004
(projects are listed by: title; project leader(s); lead state; and amount

funded)

Irrigation scheduling for small fruit crops Rieger GA \$3,800

Comparison of runner-tip production among classes of certified nursery stocks of strawberry cultivars Pesic-VanEsbroeck, Ballington, Fernandez NC \$5,000

Virus study in blackberry Fernandez, Pesic-VanEsbroeck 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 SC \$5,000

Biology and management of anthracnose in strawberry production in the southeast Louws NC \$5,000

Off-season strawberry production Straw TN \$5,000

Enterprise cost analysis for rabbiteye blueberries, southern highbush blueberries in soil and southern highbush blueberries high density in pine bark beds Fonash, Krewer GA \$5,000

Identifying the limiting factor for effective pollination period and fruit set of rabbiteye blueberries Nesmith GA \$3,800

Evaluation of herbicides for yellow and purple nutsedge and annual sedges in young blueberry fields Czarnota GA \$4,000

Evaluation of wintertime sprays of soybean oil to delay flower bud phenology and thin fruit of rabbiteye and southern highbush blueberries Deyton, Sams TN \$5,000

Evaluation of floating row covers containing micro-encapsulated phase-change chemicals for frost protection of strawberries
Sams, Deyton TN \$5,000

Optimization of chitosan coatings to extend shelf life of fresh fruits Zivanoic, Mount, Draughton, Sams TN \$5,000

Extension Projects Sponsored by the Southern Region Small Fruit Consortium in 2004 (listed similarly to research projects)

Small fruit extension programs in Georgia, North Carolina, South Carolina and Tennessee Monks, Schultheis NC 2,000

Strawberry tip production Straw TN 5,000

Diagnostic tool for eastern U.S. blackberries Fernandez, Pesic-VanEsbroeck NC 3,000

A county agent in-service training on site selection for small fruits was conducted at the Edgewater Hotel May 10-11, 2004 in Gatlinburg, TN. Twenty agents from the four member state

(NC,SC,GA,TN) received full scholarships to attend. A total of 23 agents attended including two from Kentucky.

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.

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.

The program also develops research procedures and management systems for the evaluation of peanut lines. Approximately 85% of the peanuts grown in North Carolina in 2004 were of eight cultivars (NC 7, NC 9, NC 10C, NC-V 11, NC 12C, Gregory, Perry, and VA-C 92R) that were developed and released either by North Carolina State University or in cooperation with Virginia Tech University.

Regional Apple Research and Extension Position

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

This program includes ongoing evaluation of high-density apple orchard systems utilizing dwarf rootstocks with the cultivar 'Golden Delicious'. High-density orchard systems showed greatly enhanced productivity 14 years after planting (sustained at over 1000 bu/A 47,000 kg/ha), far outperforming the productivity of central leader, semi-dwarf orchard systems which are the current industry standard in the Southeast. New apple cultivars were evaluated with respect to their suitability for the region, and appropriate management techniques developed for the most promising cultivars. On-farm trials were also utilized throughout the region in close collaboration with participating growers as a technology transfer agent to demonstrate the benefits of promising new technologies for enhancing fruit quality and/or production in a commercial context. An Integrated

Orchard Management Guide for Commercial Apples in the Southeast was developed, updated and disseminated to all commercial apple growers in the Southeast.

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 74 faculty with research and extension appointments who led integrated projects in 2004. Of those, 67 were supported by Hatch funds along with state, federal and other sources. Hatch expenditures for 62 of these projects amounted to **\$1,976,286** which was **more than 30.15%** of the 2004 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	<i>Project #</i>
Assessing farming system sustainability and research support for organic agriculture production	6625
Production strategies for improved vegetable production and alternative crops for diversification	6596
Weed management for small fruits and vegetables	6735
Cultural management of strawberries and grapes	6324
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
Integrated peach disease anagementm	6160
Management of arthropods on fruits and vegetables and Western North Carolina	6402
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
Small fruit diseases and their control	6747
Small fruit production systems	6681
Development, evaluation and promotion of underutilized and novel ornamental plants	6137
Genetic and production environmental influences on processing and planting quality of nutritionally enhanced soybean seed	6632
Management of arthropod pests of turf and peanut	6731
Ecology and management of European corn borer	0205
Plant nutrition programs for mountain crops	6558
Weed management and growth regulators for agronomic crops	6417
Precision agriculture for agronomic crops and nitrogen management for corn in Eastern	6425
Crop improvement strategies	6515
Biological control of arthropod pests in weeds	0303

Weed management and turf grass and forages and plant growth regulators for use in turf	6704
Development and refinement of strategies for peanut production in North Carolina	6466
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
Nutritional strategies to improve the growth, productivity, and profitability of dairy cattle	6605
Improving reproduction and management of dairy cattle	6600
Genetic improvement in pork production systems and understanding genotype by environmental interaction	6496
Mycotoxins and their effects on dairy cattle	6348
Strategies to increase meat goat production	6701
Nutrient requirements of swine for profitable production	6495
Maximization of laying hen performance Economic Return, and Egg Quality	6184
Fish food ingredients produced by solubilization/reprecipitation	6616
Mountain aquaculture research	6153
Integrating crops and livestock systems	6602
Price risk management strategies in food and grains marketing	6510
Economic decision support for sustainable ag products	6528
Economics of adoption of agricultural technologies	6610

Assessing farming system sustainability and research support for organic agriculture production

Project 6625

An interdisciplinary, interagency group developed an alternative food systems model and implementation plan for swine that supports independent producers and protects the environment while adding economic and social value to North Carolina's rural communities. The approach is to partner with a widening circle of well-defined consumer groups that will commit to purchasing pork products these farmers produce as they shift to more sustainable methods. Several major environmental groups have signed up to participate as the "market" in this initiative.

Production strategies for improved vegetable production and alternative crops for diversification

Project 6596

To meet increased demand for seedless watermelons, commercial seed companies developed new pollinizers that take up minimal space and increase production on a per acre basis, but information as to whether pollinizers will work in a commercial watermelon production system on a consistent basis is lacking. Pollinizer tests in 2003 indicated that an increased yield of seedless watermelon of between 10 to 25 percent could be realized using this method. However, another test in 2004 showed no benefit from dedicated pollinizers compared to traditional pollinizers. In fact, some growers

reported that dedicated pollinizers were ineffective as pollen sources. Based on 2004 results, growers should exercise caution in using dedicated pollinizers.

Weed management for small fruits and vegetables

Project 6327

Research identified control measures for nutsedge and Palmer amaranth, both troublesome weeds in sweet potatoes. Emergency registration packages for the use of Sandea herbicide for nutsedge and Dual herbicide for Palmer amaranth were prepared and submitted to the North Carolina Department of Agriculture and Consumer Services. Growers are now able to save millions of dollars by controlling Palmer amaranth and yellow and purple nutsedge before these weeds cause devastating effects to yield and quality of sweet potatoes.

Cultural management of strawberries and grapes

Project 6324

Two workshops were organized on managing anthracnose fruit rot, a strawberry disease that is increasingly widespread and difficult to manage for North American strawberry nurseries and fruit growers. The workshops were videotaped and reproduced as a three-CD set. This educational program is designed to be especially useful to Cooperative Extension agents. The program assists agents in their general understanding of anthracnose fruit rot and points out the importance of tying together certification standards and micropropagation in an integrated approach to managing this pathogen in the nursery to achieve healthier plant supplies for growers.

Post-harvest quality maintenance of horticultural crops; influence of orchard management on tree growth; rootstock and interstem effects on pome and stone fruit trees

Projects 6717, 6196 and 1840

Faculty conducted research to address major horticultural issues limiting tree fruit production in the Southeast. Educational programs were developed for growers and potential growers that provide the latest production information available on horticultural management. Educational programs have taken the form of publications, educational meetings, field days, tours and on-farm demonstrations. As a result, traditional fruit growers are adopting and planting newer rootstocks in higher density systems with higher value cultivars that have a greater potential for consistent cropping and higher economic returns.

Farming system impacts on strawberry and tomato diseases and soil microbial ecology: short and long-term

Project 6641

Interdisciplinary, multi-state and (stakeholder) participatory research, extension and educational programs were implemented to evaluate, adopt and develop alternatives to the use of methyl bromide in strawberry and vegetable production systems. From 2000-2004, 37 Phase I trials (research conducted on research stations to evaluate new products or farming practices) and 22 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 42 research and extension articles or abstracts were published. Results were translated to key stakeholders through 11 field and agent training programs and more than 21 presentations at grower meetings and commodity conferences. Research projects focused on development of integrated approaches to manage key soilborne pests.

Integrated Peach Disease Management

Project 6160

Many peach cultivars are highly susceptible to a bacterial disease, bacterial spot, that can render the fruit unacceptable. Growers often wait to observe the disease before applying the limited chemicals available. The use of chemical sprays in this manner failed to provide adequate disease control. After analyzing weather data, researchers determined that in years when the disease was severe there were frequent periods of rainfall during bloom and in the following three to four weeks. Sprays containing copper were applied prior to and during this period. This research has defined the critical fruit infection period as occurring early in the growing season near time of bloom rather than continually until fruit have ripened, thus potentially reducing the number of sprays while reducing fruit lost to this disease. The management strategy developed from this research is the basis for chemical control of bacterial spot on peaches in the Eastern U.S.

Management of arthropods on fruits and vegetables and Western North Carolina

Project 6402

Identification of the sex pheromone of the dogwood borer, an increasingly important pest of apples, has led to the development of more effective monitoring techniques, which will enable scientists to study the biology and ecology of this pest. The sex pheromone also holds promise for management of borers through mating disruption or mass trapping programs. Testing of new management strategies is planned for the next growing season.

Developing new crops and sustainable production systems for vegetables and medicinal herbs

Project 6595

Faculty facilitated a contract between growers and buyers of medicinal herbs. Seventeen growers and five buyers participated in the project. Buyers advised on herbs to be grown, how to handle and test the herbs, and quality issues. Growers produced California poppy, valerian, Echinacea purpurea and dandelion. Faculty provided farmers with assistance in growing and marketing their crops. Soil testing, tissue analysis and heavy metal testing of the herbs were also provided. A special effort was made to use farmers' existing equipment to handle the herbs. Many of these crops are still growing and will be harvested in 2005. Some harvested crops are in the process of being sold. There were some successful crops and profitable sales. For example, six California poppy growers grew, harvested and sold their herbs to buyers. The prices paid to the growers for dried material ranged between \$8 - \$9 per pound. Budgets are being developed that will show the costs of production and potential profitability of some of these crops.

Apple disease management

Project 6223

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

Processes limiting pollen development and release under heat stress in tomatoes and other crop plants

Project 6223

Research demonstrated that pollen release and pollen germination are well correlated with the ability of cultivars to set seeded fruit. Thus, pollen release represents a promising characteristic in cultivar selection for fruitset in hot, humid environments. This may be a useful characteristic in screening other heat-sensitive crops. Research also demonstrated interactions between heat and humidity stress and documented changes in carbohydrate and enzyme levels in the pollen and anthers of tomato and pepper plants that are affected by heat stress and that are related to pollen performance.

Small fruit diseases and their control

Project 6747

Blueberry cultivars grown in northern states are neither climate adapted or disease resistant in the hot, humid South. As a result, “minor” diseases such as leaf spots and stem cankers become major impediments to production. In an on-going effort, U.S. Department of Agriculture and North Carolina State University plant pathologists have worked hand-in-hand with plant breeders to develop disease-resistant blueberry cultivars adapted to low-chill climates. Disease investigations, control practices, and recommendations tailored for the extended growing season of the South have been under continuous development.

Small fruit production systems

Project 5830

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

Development, evaluation and promotion of underutilized and novel ornamental plants

Project 6137

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

Genetic and production environmental influences on processing and planting quality of nutritionally enhanced soybean seed

Project 6632

Soybean and peanut phytotron studies were completed in 2004. These studies evaluated the influence of temperature during seed development on subsequent seed quality of high oleic soybeans and peanut varieties. Field studies were also conducted in 2004. The final field study of soybean planting date, row width and harvest date was planted, while analysis will be completed in 2005. The final field study to evaluate planting date and harvest date influence on high oleic peanuts was conducted, with samples to be processed and analyzed in 2005.

Management of arthropod pests of turf and peanut

Project 6502

Research focused on the impact of using various management strategies to minimize the incidence of tomato spotted wilt virus in peanuts. An additional study focused on the incidence of southern corn rootworm injury as related to soil characteristics, variety selection and planting date and yield impact. A publication focusing on the tomato spotted wilt virus advisory was published and was widely used by growers. This research and extension effort has produced a rootworm advisory that provides sound decision-making principles for southern corn rootworm insecticide use. The tomato spotted wilt virus risk index has been validated and presented to growers. Its full implementation took place in 2003, and research indicates that by selecting the appropriate complement of cultural practices in 2003 and 2004 growers may have reduced the incidence of tomato spotted wilt virus in peanuts by more than 50 percent.

Ecology and management of European corn borer

Project 0205

Field tests using seed coatings to protect corn from wireworms and southern corn billbug indicated that two chemical coatings, clothianidin and thiamethoxam, effectively protected corn from these pests. Both treatments were commercialized for the 2004 growing season. A vigorous outreach campaign educated growers, county agents and dealers of the advantages of this new technology. Insect control, human safety, and the environment are all benefiting by replacing old insecticides with clothianidin or thiamethoxam seed coatings on planted corn seed. The new products also save time and effort. New seed treatments are priced competitively with the older products but benefit the grower with improved yields. Tests showed that insect control was equal to or better than older standard granular insecticides.

Plant nutrition programs for mountain crops

Project 6558

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

Weed management and growth regulators for agronomic crops

Project 6417

As more herbicide-resistant crops are grown, problems with volunteer crops increase. Effective strategies were developed to control volunteer Roundup Ready cotton in Roundup Ready soybeans and vice versa. Additionally, extensive use of herbicide-resistant crops and the associated limited spectrum of chemistry can and has led to weed shifts. Research has identified suitable herbicide combinations to slow or prevent weed shifts. Scientists have also identified a new invasive species that could potentially be devastating in current herbicide-resistant crop management strategies. A control program has been developed and is ready to implement it if this new weed becomes a problem.

Precision agriculture for agronomic crops and nitrogen management for corn in Eastern North Carolina

Project 6425

Soil tests for mineralizable nitrogen have the potential to predict how much nitrogen to apply at planting, 3) the remaining nitrogen can be applied as late as stage VT without reducing corn yield, 4) remote sensing of corn color using an infrared photograph of the field can accurately predict how much nitrogen to apply at VT, 5) a model for predicting corn nitrogen fertilizer requirements was successful when used on farmer fields, and 6) nitrogen management systems using both an early and late application based on soil tests and photographs of the field at VT reduced the amount of nitrogen required to grow corn and reduced nitrates in the ground water. Growers using this system can decrease nitrogen requirements by 5 to 10% while actually increasing yield particularly in years with drought stress.

Crop improvement strategies

Project 6515

Two guides, a Pansy Production Handbook and Pansy Disorder Photocards, were developed to help greenhouse growers monitor their crops and prevent crop losses. These guides provide the latest information about production practices and provide an in-house diagnostic guide when problems occur.

Biological control of arthropod pests in weeds

Project 6223

Insect populations and crop damage were compared in organic and conventional cropping systems, and beneficial insect habitat use on organic farms was evaluated. Workshops and training on these subjects were provided to audiences across the state. Quality control studies of commercially available beneficial insect habitat seed mixes are providing a way for growers to distinguish between quality products and suppliers, something they were previously unable to do. 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 improve their insect management systems.

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.

Development and refinement of strategies for peanut production in North Carolina

Project 6466

Results of tillage studies indicate that reduced tillage systems can be as successful as conventional tillage systems for peanuts in some but not all situations. It appears that peanuts produced in reduced tillage systems on coarse-textured soils respond equally as well as conventional tillage systems. In contrast, positive peanut response to reduced tillage systems on fine-textured soils may be less consistent. A risk advisory was published in 2004 to assist peanut growers in transitioning to reduced-tillage systems. Research also suggests that twin-row seeding can increase yield in some but not all situations, and that tomato spotted wilt virus incidence will be lower in twin-row plantings compared with single-row plantings. These data have been used to develop a multi-state risk advisory to help producers manage tomato spotted wilt. Interactions among agrichemicals were defined in

numerous experiments, which will lead to a better understanding of why pest control practices fail in some instances and will help producers use crop protection chemicals more efficiently. An extension guide was published in 2004 to address the issue of agrichemical compatibility.

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

Project 6527

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

Use of alternative supplements in grazed, hayed and ensiled forage systems for beef cattle

Project 6480

The North Carolina Cooperative Extension ruminant nutrition program works both directly with producers and through extension agents to enhance and expand the use of byproducts in feeding programs. In 2004, more than 3,000 tons of recycled poultry bedding, 7,000 tons of soybean hulls, 4,500 tons of dry corn gluten feed and 8,000 tons of wet corn gluten feed, and 5,000 tons of other miscellaneous byproducts were used by clients for a realized savings of more than \$1 million.

Nutritional strategies to improve the growth, productivity and profitability of dairy cattle

Project 6605

Feeding calves a high protein milk replacer and calf starter combination to accelerate growth is being evaluated. Preliminary results indicate an increase in average daily gain of about 1/3 pound per day through the first 84 days of life using this higher protein milk replacer program. Improving growth in calves can reduce the time to first breeding and thus reduce the age at first calving.

Improving reproduction and management of dairy cattle

Project 6600

Dairy grazing studies at North Carolina State University have demonstrated that although pasture-based dairy production may result in less milk per cow, there are enough efficiencies gained otherwise to be economically competitive with confinement feeding systems. Although improved grazing systems are used on a small percentage of farms, there is increasing interest in the 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 is working to provide objective information for producers considering this option.

Genetic improvement in pork production systems and understanding genotype by environmental interaction

Project 6496

The Pork Information Gateway (PIG) was organized and an editorial board of 16 members from 10 states appointed in 2004. PIG is a nationwide, refereed source of information for America's pork producers being created by swine educators and the National Pork Board. PIG consists of electronic

publications housed in three centers: a Resource Center (factsheets and educational materials), an Answer Center (frequently asked questions) and a Learning Center (distance learning and certification). The Pork Information Gateway will have an enormous impact on how information is delivered and technology is transferred to America's pork producers when it is released in 2005.

Mycotoxins and their effects on dairy cattle

Project 6348

Ration formulation using alternative feeds and based on feed analysis has increased annual dairy farm profits by \$100 per cow. More than 80 percent of North Carolina dairy producers are using these feeding recommendations. Dairy producers have adopted measures to prevent mycotoxin contamination of feed and have learned to prevent and to recognize and treat problems. These adopted feed practices are estimated to have increased annual dairy farm profits by \$10 million. They have also improved the safety and quality of North Carolina produced dairy products.

Strategies to increase meat goat production

Project 6701

North Carolina State University faculty members played an integral role in the organization of the North Carolina Meat Goat Producers Coop and continue to work with the organization. As a result, 660 farm families from 65 counties and four states are now certified members of the cooperative. Training sessions were held to certify 38 North Carolina Cooperative Extension agents interested in working with district affiliates of the cooperative. The coop holds an annual meeting every March, organizes an annual farm tour, and publishes a monthly educational newsletter. Brochures advertising the coop and goat meat recipes have been developed for distribution to the general public, restaurants and at two welcome centers on I-95. A coop website was developed, and goat meat can be ordered on-line. The coop also works with three slaughtering/processing plants.

Nutrient requirements of swine for profitable production

Project 6495

Studies determined the effect of removing fiber fractions from corn through processing (dehulled, degermed corn) on pig performance and excretion of nutrients. The effect on performance of nursery pigs, growing-finishing pigs and sows was minimal when fiber was reduced, and improvements in feed efficiency were observed. Nutrient excretion was drastically reduced in pigs fed processed corn products. Through nutritional strategies, a reduction of 20 to 50 percent 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.

Maximization of laying hen performance, economic return and egg quality

Project 6184

As part of the North Carolina Layer Performance and Management Test, faculty examined alternative molting programs for their effectiveness as related to the industry standard program of fasting. Another goal is to understand the fast as a component of the molt program. These experiments included a survey of the microbial shedding of laying hens subjected to alternative molting programs. Test reports are sent to all North Carolina producers, while an additional 315 reports are sent to producers and industry representatives throughout the United States and in 16 other countries. The primary breeders and egg companies use the test in increasing intensity to compare and evaluate strains and the different environments that are imposed upon them.

Fish food ingredients produced by solubilization/reprecipitation

Project 6616

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

Mountain aquaculture research

Project 6153

In 2004 and continuing into 2005, extension collaborators in North Carolina, Idaho and West Virginia set up yield verification trials with 10 cohorts or lots of trout on trout farms in those states. During the trials, fish production parameters of interest such as mortality rates, feed rates and sizes, feed conversion, stocking densities and water quality measures were gathered by the producers and confirmed by the extension collaborators. Each group of fish was tracked from stocking until final harvest. The Extension collaborators reported back to the producers on the current status of the fish and how they were performing relative to other locations. When unexpected values were discovered, such as a sudden rise in feed conversion, corrective recommendations were provided. On two farms, rapid adjustments were made to the feeding rate and to the feed size used. In both instances, these adjustments helped prevent production losses. Researchers from North Carolina State University, the University of Idaho and the University of Arkansas - Pine Bluff also surveyed well-defined segments of the trout industry in North Carolina and Idaho to gather detailed and accurate economic information regarding production costs and the cost/benefits of implementing additional requirements for effluent treatment. The economic models developed were provided to EPA for use in determining appropriate guidelines and possible new regulations for the trout industry. On an individual farm level, cooperating facilities saved thousands of dollars in potentially lost revenues after adopting the practices recommended by the Extension collaborators. The Extension collaborators verified the improved production efficiency resulting from their recommendations, as well as strengthening ties with the producers.

Integrating crops and livestock systems

Project 6602

Sustainable agriculture programs are identifying opportunities for niche marketing such as direct marketing (green labels, farmers markets and community-supported agriculture) and organic production. Meat goat production research is a project that combines controlled grazing technologies with alternative enterprise development. The creation of a meat goat-marketing cooperative in North Carolina is a concrete example of sustainable agriculture program impact.

Price risk management strategies in food and grains marketing

Project 6501

The North Carolina Grain Growers Cooperative proposed the development of a large biodiesel plant to be located in Mount Olive, NC. This plant will demand a significant amount of soybean oil and in turn have a positive impact on crush margins and soybean basis in the surrounding area. This project has enormous potential, but there are many complicating economic factors at play. North Carolina State University faculty researched and evaluated the economic feasibility of proposals developed by

consultants. After careful analysis and several presentations, talking points involving critical economic factors that need further consideration were developed. These talking points were shared and discussed with major stakeholders at several meetings. The analysis helped shaped further investigation into the project. Based on this further analysis, the proposal recently received a significant amount of funding and an equity drive to secure the remaining funds to move forward is underway.

**Economic decision support for sustainable ag products
Project 6625**

North Carolina State University economists used survey data from USDA-NASS to compare the technical, environmental and cost efficiency of pesticide use in conventional and transgenic cotton production. Substantial heterogeneity was found in technical and environmental performance and in costs among the cotton growers in the sample. The environmental efficiency of stacked gene cotton growers was significantly better when compared with growers of herbicide-tolerant and conventional cotton, respectively. In contrast, no statistically significant differences were found for pest control cost. The follow-up regression analysis related the efficiency scores to grower attributes, field attributes, bio-physical production environment and to cotton seed type. The regression results confirmed the importance of stacked gene cotton for improving the environmental efficiency of pesticide use in cotton. In contrast, seed type was not significant in explaining differences in cost efficiency among North Carolina cotton growers.

**Economics of adoption of agricultural technologies
Project 6610**

Multiple studies and publications have been produced such as: “Southern cotton farmers’ perceptions of environmental benefits from precision agriculture;” “The role of public goods characteristics in the adoption of a new biotechnology: The case of corn rootworm-resistant corn;” “The Net Benefits, Including Convenience, of Roundup Ready® Soybeans: Results from a National Survey;” “Factors Affecting Southern Cotton Farmer Adoption of Precision Technology Sooner than Later;” “Measuring Differences in Pesticide Use from GM Crop Adoption;” “Non-Pecuniary Benefits from Roundup Ready Soybean Adoption;” “Sources of Funding for New Swine Waste Management Technologies in North Carolina;” and collaborated with Ag Engineering to calculate the economic return from sub-surface drip irrigation.

<p>GOAL 2 A SAFE AND SECURE FOOD AND FIBER SYSTEM</p>	
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<p>Enhancing food safety through control of foodborne disease agents</p>	<p>0295</p>
<p>The poultry food system: A farm-to-table model</p>	<p>0292</p>

**Enhancing food safety through control of foodborne disease agents
Project 0295**

Poor sanitation programs can cost a large food processor \$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 indicates that *Salmonella* species populations and their prevalence on commercial broiler farms were not impacted by individual farm, season or flock age, but collectively, they did influence *Salmonella* populations. While this research did not relate the observed poultry litter properties to *Salmonella* populations, the litter populations on some farms were significantly impacted by season and flock age. Based on data obtained from grower management surveys, it appears that rearing birds on newer litter and not using litter treatment products may contribute to higher *Salmonella* litter and fecal populations. Efforts to determine the incidence and quantify pre-harvest *Salmonella* populations, such as described in this study, can aid in the development and testing of new and effective on-farm pathogen control strategies. These on-farm control strategies will ultimately lead to a reduction in the flock contamination level entering the processing plant.

<p>GOAL 3 A HEALTHY, WELL-NOURISHED POPULATION</p>

Insect and manure management in poultry systems: Elements relative to food safety and nuisance issues	1006
Biology and control of nuisance vector arthropods in North Carolina	6752

Insect and manure management in poultry systems: Elements relative to food safety and nuisance issues

Project 1006

Research has focused on fly transmission of *Salmonella* and Newcastle disease virus. A unique trapping system to collect flies for pathogen monitoring was used to demonstrate that house flies are capable of harboring Newcastle disease virus beyond 96 hours. The risks for the poultry industry relative to the practice of mixing insecticides and disinfectants to control poultry pests and sanitize poultry houses were identified. Such practices reduced the efficacy of many commonly used chemicals. Results of this study clearly demonstrate the implications for the spread of pathogenic agents.

Biology and control of nuisance vector arthropods in North Carolina

Project 6479

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.

<p>GOAL 4 AN AGRICULTURAL SYSTEM WHICH PROTECTS NATURAL RESOURCES AND THE ENVIRONMENT</p>

Environmental nursery crop production	6224
Precision agriculture for agronomic crops and nitrogen management for corn in Eastern North Carolina	6652
Evaluation of tillage practices, organic production, and trickle fertigation for nutrient management	6648
Development of plant pathogens as bioherbicides for weed control and weed management in landscapes	1001
Improving sediment and erosion control measures	6559
Nutrient and by-product utilization and health of turkeys and broilers	6343
Effect of management on turkey production, turkey reproduction and turkey waste handling	6390
Community-wide impacts and management of septic systems	6372
Waste management systems	6454
Engineering processes to enhance nutrient management and reduce environmental impacts of animal manure	6575
Evaluation and modeling of riparian buffer performance in the Neuse River Basin	6609
Improved efficiency of water reuse aquaculture systems	3975
Aquaculture of southern flounder and improved water quality management of ponds in Eastern North Carolina	6387
Developing a soil test-based nutrient management decision support system for North Carolina	6716
Animal Manure and Waste Utilization, Treatment and Nuisance Avoidance	1000

Environmentally compatible nursery crop production practices

Project 6224

Pine bark and sand are the most commonly used ingredients to grow nursery crops in containers in the Eastern United States; however, these substrate components offer little water or nutrient retention. Research showed that a clay amended pine bark substrate engineered to retain water and fertilizers can also increase growth and provide an alternative Best Management Practice without costly infrastructure changes.

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.

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

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

Improving Sediment and Erosion Control Measures

Project 6559

Research demonstrated that modification of typical sediment basins will increase sediment removal from 60-70 percent to more than 90 percent. Researchers also found that very small amounts of a very safe organic chemical can cut turbidity by more than 90 percent, resulting in relatively clear water.

Nutrient and by-product utilization and health of turkeys and broilers

Project 6343

Appropriate dietary supplementation of enzymes, amino acids and organic minerals to poultry feed reduced emissions of phosphorus, nitrogen and other minerals by improving diet digestibility by more than 5 percent. Dietary supplementation of novel enzymes, oligosaccharides, probiotics and immunoglobulins was found to stabilize gut microflora, discourage enteric pathogen colonization and improve enteric health. More than 70 percent of poultry feed now includes supplemental enzymes to improve nutrient utilization, resulting in a 5-10 percent reduction in phosphorus and nitrogen emissions, better nutrient utilization and improved enteric health. The use of enzymes and feed additives reduces feed costs by at least \$.40 per ton, resulting in a savings of over \$2 million to the poultry industry.

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

Project 6390

The growth performance and fecal phosphorus excretion of turkey poults fed diets containing genetically modified low-phytate and normal soybean meal were compared. The feeding trial showed

that the low-phytate soybean meal diet produced bird performance equal to that of the normal soybean diet, while the low-phytate diet reduced fecal phosphorus.

Community-wide impacts and management of septic systems

Project 6372

A pilot study was conducted with the Wake County, North Carolina Department of Environmental Services to determine how well septic systems are functioning. Study results indicated that the vast majority of systems (90 percent) were operating well; however, the failure rate observed (8-10 percent) was agreed to be too high. The study identified specific operating and maintenance factors that had significant effects on system failure rates along with factors that did not influence failure rates. Based on this study, the Wake County Department of Environmental Services has identified 10 important lessons learned and is developing recommendations to address these issues.

Waste management Systems

Project 6454

Alternative waste management technologies for swine are being evaluated, including economic feasibility determinations. Environmental variables include the impact of animal waste to surface waters and groundwater, emission of ammonia, emission of odor, release of disease-transmitting vectors and airborne pathogens, and nutrient and heavy metal contamination of soil and groundwater. Two of the technologies considered were shown to be capable of meeting these standards. These technologies are: 1) a solids separation/nitrification–denitrification/soluble phosphorus removal system and 2) a high solids anaerobic digester system. The data also indicate that with technical modifications and/or combination of other technology unit processes, additional technologies considered may meet the environmental performance criteria.

Engineering processes to enhance nutrient management and reduce environmental impacts of animal manure

Project 6575

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

Evaluation and modeling of riparian buffer performance in the Neuse River

Basin

Project 6609

North Carolina Cooperative Extension faculty worked with local landowners to develop 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. The hydrology and surface water quality associated with these best management practices were monitored 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 the 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. Based on long-term simulation analysis, predicted nitrate-nitrogen reduction was most effectively accomplished when controlled drainage and a nitrate management plan were used in conjunction with one another. If implemented separately, a nitrate management plan was predicted to

be about 50 percent more effective than controlled drainage alone. The cropping system also impacted the drainage rate and nitrate loss from the fields.

Improved efficiency of water reuse aquaculture systems

Project 3975

Research suggested that dissolved inorganic nitrogen can be effectively removed from the effluent stream from intensive fish production systems. This simple technology utilizes wood chips as a media on which to grow naturally occurring bacteria to break down potentially harmful nitrate in the water to harmless nitrogen gas.

Aquaculture of southern flounder and improved water quality management of ponds in Eastern North Carolina

Project 6387

Researchers have succeeded in producing commercial-scale quantities of weaned southern flounder fingerlings and are completing growout trials in recirculating systems at different salinities. This research has established the importance of all-female stocks and underlined the research efforts directed toward gynogen production. Significant strides have been made in domesticating southern flounder, and researchers are close to releasing a fast-growing strain to the first commercial producer in North Carolina.

Developing a soil test-based nutrient management decision support system for North Carolina

Project 6716

A Nitrogen Loss Estimation Worksheet was developed as an accounting tool to be used by agricultural producers in the Tar-Pamlico and Neuse River basins to track best management practice implementation and nitrogen reductions associated with best management practice implementation. Using this tool, counties are able to determine the extent of best management practices needed to meet a 30 percent nitrogen reduction goal.

Animal manure and waste utilization, treatment and nuisance avoidance

Project 1000

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

GOAL 5 ENHANCED ECONOMIC OPPORTUNITY AND QUALITY OF LIFE FOR AMERICANS

Implications of technological and social changes for the food system	6465
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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

Implications of technological and social changes for the food system

Project 6565

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

Economics of socially optimal pork production

Project 6706

Anticipated changes in livestock feeding, housing and manure management in concert with dramatic changes in global meat demand and the global structure of farming require new economic insight. Contributions of informed economic analysis and perspective at the farm, market, region, national and global level will be critical in the implementation of efficient policy and livestock production systems. Research is broadening the economic scope of agriculture and silviculture to include production of energy, fertilizer, other non-food and non-fiber products, aesthetic and environmental services, as well as a safe use for otherwise wasted water, energy, nutrients and other by-products of human activities.

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

Research is assessing the overall economic impact on counties of residential development. This analysis takes into account an accurate projection of the benefits to the county’s residents and businesses, an accurate estimate of the likely costs of the project to the county’s residents and costs imposed on environmental assets.

Summary:

Research-Extension Integrated Project Initiatives with Hatch Funding Sources involved 67 Scientists who led 62 projects.

Total Hatch funding allocated and expended on the 62 projects for FY 2004: \$1,976,286.31

Total Hatch budget allocation for 2004 was \$6,554,500.22.

Percent of total Hatch funds allocated to Integrated projects amounted to 30.15%

**North Carolina Agricultural Research Service
HATCH EXPENDITURES FOR 2004
FOR INTEGRATED RESEARCH-EXTENSION ACTIVITIES
by National Goal Area**

FY 2004

GOAL 1:

An Agricultural System that is Highly Competitive in the Global Economy \$1,404,232

GOAL 2:

A Safe and Secure Food and Fiber System \$31,100

GOAL 3:

A Healthy and Well-Nourished Population \$51,905

GOAL 4:		
An Agricultural System Which Protects Natural Resources and the Environment		<u>\$401,199</u>
GOAL 5:		
Enhanced Economic Opportunity and Quality of Life for Americans		<u>\$87,850</u>
	Total	\$1,976,286

Certification:



3-23-2005

Steven Leath,
Interim Director

Date