NORTH CAROLINA
AGRICULTURAL RESEARCH SERVICE

PLAN OF WORK

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North Carolina Agricultural Research Service
College of Agriculture and Life Sciences
North Carolina State University
Campus Box 7643
Raleigh, North Carolina 27695
919-515-2717
http://www.cals.ncsu.edu/research/

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, forestry, and family and consumer sciences. Its research projects involve NC 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 and life sciences;
- conserve and improve the state's natural resources and environment;
- improve the health, well-being and quality of life of all citizens of North Carolina.

Numerous facilities are utilized in conducting research on and off campus. On-campus facilities include many laboratories, some highly specialized (i.e., molecular imaging, genomic sequencing, soil analysis, x-ray crystallography, etc.); two greenhouse ranges; the Phytotron controlled environment facility; the Biological Resources Center small animal facility, and the Pesticide Residue Laboratories, among others. Off-campus research facilities include nine field laboratories near campus with extensive animal and crop production capabilities and facilities for agricultural and municipal waste management research; regional research and extension centers with resident research faculty in both western and eastern North Carolina; and 16 agricultural research stations spread throughout the state, including the Center for Environmental Farming Systems, which specializes in sustainable agriculture research.

NCARS personnel include 350 research faculty accounting for approximately 180 full-time scientist equivalents, most on shared appointments with academics or extension. Working with these faculty are over 280 graduate students, researchers and research assistants; 450 laboratory and field technicians and 90 clerical staff. These faculty and support personnel conduct basic and applied research in over 550 projects to support more than 70 commodities as well as many life science industries.

The following five-year Plan of Work covers the full range 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.

PLAN OF WORK CERTIFIED BY:

Johnny C. Wynne, Director
NC Agricultural Research Service
Campus Box 7643
North Carolina State University
Raleigh, NC 27695

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I. PLANNED PROGRAMS

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

Program Area 1:
Technologically Integrated
and Sustainable Crop and
Livestock Production Systems

Subprogram Area 1a:
Crop Production Systems

Statement of Issue

The development of improved crop production systems has long been the mainstay of research conducted in commodity departments such as Crop Science and Horticultural Science with support and collaboration from departments such as Soil Science, Biological and Agricultural Engineering, Poultry Science, Plant Pathology, Agriculture and Resource Economics, Food Science and Biochemistry. Research has focused on breeding and genetics work designed to develop improved varieties with superior disease resistance and quality; mechanization in all phases of crop production from planting to harvest; technologically advanced production systems; and post harvest handling. Advances in these areas have given producers the ability to competitively produce quality products, which directly benefits the consuming public.

In recent years declining grain prices and pressures exerted on tobacco production have impacted our research efforts. Programs have been redirected to explore and examine diversification of crop production in North Carolina with alternative and specialty crops. In addition, economic downturns in agronomic crops and sensitivity to environmental concerns regarding pesticides, nutrients and animal waste have spurred an increase in research on sustainable production techniques.

To remain competitive in a national and global agricultural economy, it will be necessary for our producers to become even more efficient in the production of traditional crops. They must also diversify their operations to incorporate alternative and specialty crops in their mix, thus spreading their risk. In addition, consumers are becoming more educated concerning food safety, quality and nutrition. It will, therefore, be incumbent upon our producers to supply a quality, nutritious and safe product to the market place.

Performance Goals

1. Develop improved pre- and postharvest handling techniques for field, fruit and vegetable crops.

2. Develop improved production management systems for field, fruit and vegetable crops.

3. Improve the acceptability/quality of field, fruit and vegetable crops.

Key Program Components
A total of 77 different North Carolina Agricultural Research Service projects in nine departments involve crop production systems. Key program components are listed below in relation to the three performance goals listed above.

Performance Goal 1.
Major areas that will be addressed include mechanization of crop planting and harvest and development of improved post-harvest handling for crops, with emphasis on perishable crops such as vegetables and fruits. Field crops are also addressed but, the number of projects devoted to horticultural crops will be much greater in this category. Precision agriculture is another component of this goal and, of course, does require mechanization of certain operations to monitor yields and other parameters associated with crop production and quality. Some breeding and genetics as well a cultural manipulations will be addressed as they relate to constructing plant growth habit and yield traits that lend themselves to mechanical harvesting.

Performance Goal 2.
There are a total of 32 different projects underway in this category, with 15 in the fruit and vegetable area and 17 in field crops. In the fruit and vegetable area, research activities will include sustainable production systems; plant establishment; nutrient cycling and fertilizer management; stress physiology; IPM strategies for managing plant diseases; production systems for herbs and botanicals; and general cultural management practices for a number of different fruit and vegetable crops.

The projects with field crops will involve economic assessments and modeling for a number of different commodities; assessment of precision farming technology; transplant production systems; environmental factors related to productivity of various crops; reducing herbicide and chemical inputs in cropping systems; and genetic variability in cyst and root-knot nematodes.

Performance Goal 3.
This goal captures many of the resources devoted to crop production systems. There are a total of 34 different projects, with 14 in horticultural crops and 20 in field crops. Plant breeding and genetics of horticultural and field crops will comprise a large amount of the activity related to this goal. There are a number of overlaps between this goal and Goal 2, including some of the nutrient and fertility work with vegetables as well as plant establishment projects. Other areas of emphasis with horticultural crops will include nondestructive quality sensing of high-value crops; physiology of apple fruit ripening and maintenance; and influence of orchard management systems on tree fruit growth and development.

Other areas to be addressed under field crops will include chemical and animal evaluation of legumes and natives grasses in sustainable production systems; peanut cultivar and quality evaluation; mycotoxin monitoring; parameter sensing and control systems for drying agricultural commodities; and biodiversity of soybean germplasm for value-added traits.

Output Indicators: The performance goals involve research with direct application to the crop producer, with ultimate benefits to the consuming public. Anticipated outcome indicators include:

- adoption of labor saving and more efficient practices in the planting, cultivating and harvesting of crops;

- application of sustainable production techniques that result in reduced risk of off site movement of nutrients and pesticides;
- use of improved varieties that have multiple disease resistance, improved quality characteristics including taste, flavor and nutritional/health value;
- use of crop varieties adapted to a wide range of environmental conditions and physiological stresses;
- improvement in post harvest handling procedures resulting in increased shelf life and storage with minimal losses;
- use of nonchemical methods of pest control and/or reduced pesticide use through application of IPM strategies; and
- application of precision agriculture techniques to enhance sustainability and production efficiency.

Internal and External Linkages

Internal linkages exist with many College of Agriculture and Life Sciences departments in this program area. Major players in this program area include faculty from the following departments.

Crop Science
Horticultural Science
Biological and Agricultural Engineering

Faculty in these departments will collaborate with faculty from the following departments.

Soil Science	Plant Pathology
Food Science	Biochemistry
Statistics	Entomology
Poultry Science	Animal Science
Botany	Genetics

Multi-state collaboration exists in many of the programs, both formally through SRIEG agreements and Memorandums of Understanding and informally between individual faculty at a number of land- grant institutions in the Southeast and other regions of the country. Additionally, a number of the projects involve direct and indirect international collaborations, both with individuals in other nations and through international centers in Central and South America, Europe, Africa and Asia. Both the internal and external linkages greatly enhance research efforts within this program area.

Target Audiences

Producers of field and horticultural crops in North Carolina are the primary stakeholders or clientele of this program area. However, the ultimate consumers of the commodities produced are also important customers. Although efforts are targeted for North Carolina, research related to this area often has regional, national and international implications.

Program Duration

Long-term, 5-plus years

Allocated Resources
Following are expenditure and commitment data for 1997-98.

EXPENDITURES

Source	Amount
CSREES Funds	$366,606
USDA-CGCA Funds	$162,009
Other Federal Funds	$572,688
State Appropriation	$2,731,620
Non-Federal Funds	$286,828
Total	$4,119,752

PERSONNEL COMMITMENT

Scientist Years		10.59
Professional Years	14.29	
Technician Years	29.30	
Clerical Years	10.64	
Total	64.82	

No major shifts in future resource allocations appear to be warranted; however, in view of the importance of developing sustainable agricultural practices, including organic farming techniques, more resources may have to be assigned to Performance Goal 2 (Production Management Systems for Field, Fruit, and Vegetable Crops).

Subprogram Area 1b:
Animal Production Systems

Statement of Issue
Animal production in North Carolina impacts virtually all citizens in the state by providing income, products for human consumption and use, and recreation. Production of bees, beef cattle, dairy cattle, fish, goats, horses, poultry, sheep and swine accounts for more than $4.6 billion annually in sales, representing more than 56 percent of the agricultural income in the state. This amount does not include the value of sales and services of animals associated with the pleasure industries involving horses and companion animals.

Each of the broad animal production categories listed consists of subcategories. For example, poultry production can be subdivided into broiler production, turkey production, chicken egg production, game bird production, etc. Most of these subcategories contribute significantly to North Carolina's agricultural income and each has unique set of inputs and outputs.

Animal production systems have changed during the past couple of decades, and there is an expectation that they will continue to change in the future. Certain segments of the animal industry have undergone aggregation into fewer controlling business entities and have experienced vertical integration. For example, corporate businesses now have a controlling interest in the boiler, swine and commercial fish production industries. On the other hand, many segments of the animal industry remain quite diverse and are controlled by many individuals. Beef production continues to increase in North Carolina, with increases occurring in both the number of animals being raised and the number of producers involved in the industry.

Segments of the state's animal industry that rely on the increased affluence of North Carolinians also continue to grow, with the most notable among these being the horse industry.
While animal production is located in every county in North Carolina, there are geographical areas of the state that contain concentrated production units involving animals. For example, most of the swine in North Carolina are located on the coastal plain, whereas other industries are more geographically dispersed. Certain relationships exist between intense animal production systems and the surrounding communities and land and water resources, and these relationships need investigation. At the same time, new knowledge is needed to understand the relationship of animal production systems that are more dispersed or that are confined in paddocks and apartments to surrounding communities and land and water resources.

Animal production systems are affected by both internal and external factors. Among these factors are business considerations and the biological limitations of the animals. Laws and regulations governing animal production and the expectations of society also affect animal production.

The following key components that contribute to a better understanding of animal production systems have been identified. The input of producers and users of animal products, proponents and opponents of animal production, and researchers was used to identify these components.

- Underlying Biological Processes of Animals
- Economics and Profitability of Animal Enterprises
- Impacts of Animals on the Environment
- Relationships Among Animals, Animal Housing and Equipment
- Associations of Animal Production Systems with the Health and Well Being of Animals and the Products Derived Therefrom
- Societal Acceptance of Best Management Practices

Performance Goals

1. Improve the overall biological efficiency of animal production through understanding of the basic physiological processes of animals. New knowledge gained and knowledge transferred will be the output/outcome indicators for this performance goal.

2. Investigate and develop best management practices for animals in various animal production systems that are environmentally sensitive, economically realistic and socially acceptable. New knowledge gained and knowledge applied to existing problems that result in profitable and environmental sustainable animal production will be the output/outcome indicators for this performance goal.

3. Develop, improve and enhance the structures, facilities and equipment used in animal production

systems. New knowledge gained and the transfer of knowledge into new ways to house and maintain animals will be the output/outcome indicators for this performance goal.

4. Examine relationships between animal production systems and animal uses and products for the purpose of improving consumer and societal acceptance. New knowledge gained, new services and products developed and a safer, more wholesome food supply output/outcome indicators for this performance goal.

Key Program Components
Research will focus on developing a better understanding of the following topics. Adequately addressing these topics is considered key to successfully reaching the performance goals.

- The Reproductive Performance of Livestock, Poultry, Fish and Other Animals
- Environmental Stress Experienced by Livestock, Poultry, Fish and Other Animals During Production
- Production Management Systems for Livestock, Poultry, Fish and Other Animals
- Bees and Other Pollinating Insects
- Improvement of Structures, Facilities and General Purpose Farm Supplies and Equipment
- Mechanization and Improvement of Structures Used in Production of Livestock, Poultry, Fish and Other Animals
- Production of Animal Products with Improved Consumer Acceptability

Internal and External Linkages:
Numerous linkages will be required to meet the performance goals. Within each key program component, there is an expectation that linkages will be formed internally within the NC State University community as well as with partners outside the university. Listed below are members of partnerships that have been formed previously to address these goals and that most likely will also be forged in the future.
Departments in the College of Agriculture and Life Sciences

Animal Science	Poultry Science
Biochemistry	Zoology
Toxicology	Biological and Agricultural Engineering
Agricultural Resource Economics	Crop Science
Entomology	

Colleges at North Carolina State University
- College of Veterinary Medicine
- College of Physical and Mathematical Sciences

Institutes in North Carolina
- Institute of Nutrition

Universities in North Carolina
- North Carolina A & T State University
- Duke University
- University of North Carolina at Chapel Hill

Commodity Organizations
- Numerous including North Carolina Pork Council, North Carolina Cattlemen's Association, North Carolina Dairy Producers, North Carolina Horse Council

Other Land-Grant Universities
- Numerous including Michigan State University, University of Illinois, University of Georgia, University of California-Davis

North Carolina Agribusinesses
- Numerous including Murphy Family Farms, Open Grounds Farm

International Universities and Companies
- Numerous including BASF, Novus International, Pfizer, Inc., Purina Mills, Smithfield Foods

Target Audiences

The research conducted in this area has many stakeholders and beneficiaries, including North Carolinians and those who live outside the state. A prioritized list of target audiences follows.
- Animal producers
- Consumers of animal products
- Individuals who maintain animals as pets
- The agribusiness community
- Scientists and researchers
- Students

Program Duration

Long-term, 5 years

Allocated Resources

Following are expenditure and commitment data for 1997-98.

EXPENDITURES

Source	Amount
CSREES Funds	$721,546
USDA-CGCA Funds	$22,001
Other Federal Funds	$321,477
State Appropriation	$3,097,112
Non-Federal Funds	$767,493
Total	$4,929,629

PERSONNEL COMMITMENT

Scientist Years		7.76
Professional Years	12.89	
Technician Years	41.17	
Clerical Years	2.67	
Total	64.43	

During the next five years, it is expected that the total Animal Production Systems commitment will remain at approximately $5 million, adjusted annually for inflation, and that the personnel commitment will remain consistent with the 1997-98 fiscal year. As conditions change and upon the appropriate recommendations from stakeholders, the budget and personnel inputs for this program may change.

Subprogram Area 1c:
Biological Systems

Statement of Issue

Basic research on fundamental biological systems creates the knowledge base and foundation used by scientists to improve agricultural production systems, the marketability of agricultural products and these products for human health. The growth and development of plants and animals and their response to the environment are key to productivity, marketability and sustainability. There is a need to understand the basic biochemical, physiological and genetic mechanisms that regulate these processes and to develop new methods to alter the responses of living systems to their environment. In the last decade, the new field of genomic science has changed the paradigm for basic and applied biological sciences. New technologies have allowed rapid progress in the sequencing and mapping of organisms' genomes, and advances reveal striking interrelationships in the structure and function of these genomes. Bioinformatics deals with the handling and analyzing of the vast amount of sequence, genomic mapping and expression data being generated. The area of functional genomics encompasses gene discovery, cellular and developmental biology, structural biology and genomic approaches to breeding as well as comparative studies of ecology and evolutionary biology. Genomic science approaches integrated with traditional approaches in physiology, biochemistry and genetics applied to model biological systems will provide the knowledge base needed to prevent and treat disease, identify infectious organisms and improve the yields and quality of the foods we produce and consume.

Performance Goals

1. Map, identify and analyze genes responsible for quantitative traits.

2. Characterize the structure and expression of genes and pathways required for growth, development and behavior.

3. To develop new approaches for gene transfer and gene regulation, and new methods for visualizing gene products within cells.

4. Identify biochemical factors and pathways involved in response to abiotic and biotic stresses and environmental factors such as drought, gravity, light and pathogens.

5. Elucidate the structure, function and evolution of macromolecules that are key to growth, development, defense and behavior.

Key Program Components
This program area involves more than 60 projects in 13 departments. Projects focus on the fundamental processes that regulate growth, development and responses to the environment at the cellular, tissue and organismal levels. The projects include the following overlapping research areas in model plant, animal and microbial systems.

Statistical, quantitative and evolutionary genetics of complex traits. Projects in four departments using experimental and theoretical statistical, quantitative and evolutionary genetics approaches focus on:

- The mapping and identification of quantitative trait loci;
- Quantification of the extent of genetic diversity in natural and domesticated species;
- Detection of genes affecting economic traits in plants and animals, and genes affecting human disease; and
- Reconstruction of the evolutionary history of modern species.

Analysis of genes and pathways involved in growth, development, and behavior. A large number of projects in six departments focus on an understanding of the genetics, biochemistry and physiology that impact growth, development and behavior in model systems. These include projects on:

- The identification and expression of genes and involved in a) microbial, plant, insect and mammalian growth and development, and b) insect and mammalian behavior;
- An understanding of the mechanisms of gene regulation in microbial, plant and animal systems and the development of methods for optimizing transgene expression in plants; and
- An understanding of biochemical pathways affecting growth and development in microbial, plant and animal systems.

Structure, function and evolution of macromolecules. Projects in three departments focus on an understanding of macromolecules and macromolecular complexes that are key to growth and development. These include projects on:

- The structure/function relationships of macromolecular assemblies involved in replication, translation, and protein and nucleic acid degradation;
- The thermodynamic and kinetic folding properties of proteins;
- An analysis of higher order DNA structures in vivo; and
- The molecular evolution of transcription factors.

Responses to the environment, including biotic and abiotic stresses. Projects in seven departments address responses to the environment. These focus on:

- The genetic and biochemical basis of pathogenesis in plant, animal and microbial pathogens;
- Defense responses to pathogens in plants;
- Responses to oxidative and nutrient stress in microorganisms; and
- Plant responses to external stimuli such as light and gravity.

Output indicators: These performance goals involve fundamental research on model systems, and thus, the output indicators are the dissemination of this information and its use by other scientists. Indicators include the dissemination of knowledge to scientific colleagues, postgraduates, graduate students, undergraduate students and K-12 teachers through peer-reviewed publications, technical publications, seminars, presentations at scientific conferences, classroom instruction, student laboratory training, teacher workshops, and web access to publications and laboratory protocols for teaching and research.

Internal and External Linkages
This program area includes faculty from 13 departments in the College of Agriculture and Life Sciences. These departments are:

Biochemistry
Botany
Entomology
Genetics
Microbiology
Statistics
Zoology
Biological and Agricultural Engineering
Crop Science
Food Science
Horticultural Science
Plant Pathology
Toxicology

Many projects are multidisciplinary in nature and involve faculty from different departments and/or other universities. Faculty work freely across departmental and college boundaries and various faculty are linked through a number of university programs and research and training grants, including:

the Biotechnology Faculty,
the NIH Program Project in Statistical Genetics,
the NIH Training Grant in Quantitative and Molecular Genetics,
the TriAgency (USDA/DOE/NSF) Training and Research Program,
the NASA Center of Training and Research in Gravitational Biology, and
the Keck Program in Behavioral Biology.

External linkages include the involvement of the faculty in a number of Research Triangle area groups that include scientists from the University of North Carolina at Chapel Hill and Duke University and scientists at local industry and government organizations. These include:

the RNA Society of North Carolina,
North Carolina Biotechnology Center Plant Molecular Biology Program,
Triangle Virology,
Triangle Lower Eukaryotes Group and
Triangle Arabidopsis Group.

Target Audiences
The national and international community of scientific researchers and teachers

Program Duration
Long-term, 5-plus years

Allocated Resources
Following are expenditure and commitment data for 1997-98

EXPENDITURES

Source	Amount
CREES Funds	$721,321
USDA-CGCA Funds	$77,108
Other Federal Funds	$2,466,290
State Appropriations	$4,666,484
Non-Federal Funds	$838,136
Total	$8,844,370

PERSONNEL COMMITMENT

Scientist Years	22.50
Professional Years	60.11
Technician Years	28.03
Clerical Years	5.94
Total	116.58

It is anticipated that future funding and human resource allocations for this program area will continue with roughly the same emphasis as shown in the above tables during the period of this plan of work (5 years).

Goal 1, Program Area 2:
Plant and Animal Germplasm,
Genetic Resources and Conservation,
and Plant Improvement

Subprogram Area 2a:
Crop Improvement

Statement of Issue
An adequate quantity of nutritious food is critical for a healthy human population and for sustained economic growth. To ensure continued sources of useful plant products, technologies must be enhanced to economically grow the food and fiber resources needed to feed both the human population and animal industry, as well as to supply quality raw materials to the nation's industrial complex. Plant cultivars that are grown on the state's high-quality soils are mostly productive, but on less favorable soils there can be significant declines in yields. Further, diseases and insects continue to plague field crops and orchards in all areas of the state, and they cause significant yield reductions as well as reduced quality of marketable products. In addition to field crops, orchards and vegetables, more than 2.5 million acres of forages in North Carolina supply about 70 percent of the feed resources for the state's cattle, horse, sheep and goat industries. These perennial crops provide both feed for animals and a rapid, low-cost method of utilizing animal and industrial by-products.

Agricultural industries have undergone dramatic changes during recent years as prices have greatly fluctuated and government support programs for several commodities have come under political scrutiny. If they are to continue to be economically solvent, producers must grow their products with either fewer or less expensive inputs while at the same time generating a high- quality product. In addition, producing crop products economically has become difficult as federal and state environmental regulations restrict some farm management practices and chemical use to control weeds, pathogens and other pests. Many farms

produce both plant and animal products, and management problems become more complicated as animal waste is used on cropland in place of commercial fertilizers, sometimes resulting in high concentrations of nitrogen, phosphorous, and other elements in soil and groundwater. New, innovative strategies must be developed and implemented on farms to enhance economical and environmentally sustainable crop production.

Performance Goals

1. Improve plant productivity and quality of fruits, vegetables and agronomic crops through breeding methodologies to increase yield and quality and reduce the incidence of diseases and insects.

2. Increase biological efficiency through control of metabolic processes and gene regulation in plants used for food, fiber and fodder.

3. Develop methods and strategies to more efficiently produce horticultural and agronomic crops in North Carolina.

Key Program Components
Performance Goal 1.
North Carolina Agricultural Research Service programs to improve plant productivity through improved breeding methodologies encompass a wide range of horticultural and agronomic species and research areas including: a) quantitative genetics, b) qualitative genetics, c) molecular genetics, including molecular marker technologies and transformation methodologies, d) interspecific hybridization, e) manipulation of ploidy levels, f) germplasm collection, introduction and conservation, and g) variety development. Plant breeders in the Crop Science and Horticultural Science Departments interact with a large number of faculty and programs in Agriculture Engineering, Botany, Entomology, Food Science, Genetics, Plant Pathology and Soil Science.

Plant breeding programs are being conducted to develop improved varieties and/or genetic stocks in barley, blueberries, corn, cotton, cucumber, luffa, oats, peanut, potato, rubus, soybean, strawberry, sweet potato, tomato, triticale, watermelon, and wheat. Specifically, the objectives of these programs are to:

- Develop high yielding and superior quality cultivars and germplasm lines with resistance to biotic stresses, including plant diseases caused by fungi, bacteria, viruses, insects and nematodes;
- Develop high yielding and superior quality cultivars and germplasm lines with resistance to abiotic stresses, especially to drought and soil toxicities; and
- Develop and test new breeding methodologies to improve efficiency of genotype selection.

Breeding program goals are met through a number of hybridization and plant manipulation techniques. Research involves clonal materials, cross- and self-pollinated species, annuals and perennials. Breeders of blueberries, peanuts, cotton, potato and small grains make extensive use of interspecific hybridization to introduce new genes from related wild species into the respective cultivars. Corn breeders are manipulating daylight sensitivity in a program to utilize South American land races. New germplasm resources are acquired both by plant exploration and through seed acquisition from cooperators.

Introductions are then evaluated for important disease, insect and quality traits for the respective species. Ploidy levels are manipulated to utilize simpler genetic systems at the haploid level for several autotetraploid and allotetraploid crops. Molecular marker technologies are utilized by the corn, peach, peanut, potato, small grains, soybean and other programs. Transformation technologies are used for peanut, grasses, tobacco and several other crop species.

Each commodity program has genetic components where the quality of oils, fibers, flavors, disease and insect resistance are characterized. Genotype x environment interactions are evaluated at field sites to estimate adaptability of cultivars. Variety testing programs are conducted prior to release to the user community for all major crop species grown in North Carolina.

Output Indicators:

- Release of superior cultivars for use by commodity producers
- Release of improved germplasm lines for use in hybridization programs
- Release of inbred lines for use as parents in hybrid production

Performance Goal 2.
Research in crop management has historically been crop specific, but in recent years a more systems approach has been implemented. Research projects include the major agronomic crops, cover crops, vegetables, vineyards, orchards, herbs and botanicals produced in North Carolina. A large percentage of the research focuses on quality issues during the time of plant growth and development as related to plant establishment, pest and fertility interactions, tillage practices, weed and integrated pest management, fertilizer management and harvesting methodologies. Post-harvest issues are especially important for preserving quality of apples, grapes and other fruits.
Environmental issues have a significant impact on crop management due to implementation of federal and state regulations. The effects of conservation tillage and cover crops on yields are being investigated. Soil fertility is an important component of research projects for management of nitrogen and other elements from fertilizers and animal waste. In addition, soil microorganisms play a key role in plant utilization of nutrients, and studies are underway to determine the diversity and interactions of bacteria and fungi in the rhizosphere.

The specific objectives of these programs are to:

- Develop improved cultural methodologies to increase yields of high quality plant products; and
- Understand the interactions between plants and the environment in which they are grown.

The objectives of the management projects are met at research stations across the state of North Carolina, which are generally located in the centers of the commodity production area. Both traditional and newly developed agricultural practices are tested experimentally. For example, sustainable agricultural systems are being tested at one farm using a highly integrated systems approach to both crop and animal production. Management research is multidisciplinary and involves integration of all disciplines in plant-related agriculture. This research is leading to higher degrees of specialization and modeling production practices to the ultimate benefit of a broad range of farming enterprises.

Output indicators:

- Development of New Technologies That Lead to Higher Quality Plant Products
- Higher Levels of Crop Production With Economical Management Practices
- Implementation of Best Management Practices That Lead to Production of Safe Products With Consideration for Both Growing and Surrounding Environments

Performance Goal 3.
Plant metabolism and cell functions are investigated to understand the biochemical and plant processes leading to higher yields and better quality products. Source-sink relationships are studied to direct more photosynthetic products into desired organs. Carbohydrate and sugar metabolism and protein synthesis have significant effects on harvesting and product maintenance in storage. To create more efficient plants and higher quality products, it is necessary to understand the developmental and metabolic processes leading to the plant part that is marketed.

The specific objectives of these programs are to:

- Understand biological processes which can lead to higher yields and quality of plant products; and
- Identify unique genotypes which can be utilized in applied plant improvement programs.

Output Indicators:

- Number of New Technologies Developed That Lead to Higher Quality Plant Products
- Number of New Basic Biological Principles Elicited Related to Crop Plants

Internal and External Linkages
Internally, this program area primarily includes faculty from the following departments.

Crop Science	Horticultural Science
Botany	Genetics

Faculty from these primary departments cooperate and collaborate with faculty from the following departments.

Food Science	Entomology
Plant Pathology	Biological and Agricultural Engineering
Biochemistry	Microbiology
Soil Science	Statistics

Faculty also interact with faculty in the College of Forestry. Most projects are multidisciplinary and involve several NC State faculty from different departments. Many projects involve faculty from different universities. Several projects have cooperative links with industry and commodity groups. Most projects have direct or indirect links to foreign countries in Central and South America, Europe, Africa, and Asia. Linkages with international institutes have been extremely important for crop production research.

Target Audiences
The primary audience includes the producers of agronomic and horticultural crops in North Carolina. Farmers and companies in other states and foreign countries who use the products produced in this state also benefit from enhanced germplasm for traits affecting yield and quality.

Program Duration
Long-term, 5 years

Allocated Resources
Following are expenditure and commitment data for 1997-98. Similar expenditures and personnel commitments are expected over the next five years.

EXPENDITURES

Source	Amount
CSREES Funds	$724,123
USDA-CGCA Funds	$222,771
Other Federal Funds	$352,565
State Appropriation	$6,125,954
Non-Federal Funds	$1,021,486
Total	$8,473,899

PERSONNEL COMMITMENT

Scientist years	19.67
Professional years	17.33
Technician years	88.12
Clerical Years	21.47
Total	146.59

Subprogram Area 2b:
Animal Improvement

Statement of Issue
Animal agriculture in North Carolina accounts for more than $4.6 billion of annual sales, representing more than 56 percent of the agricultural income in the state. Tremendous increases in the economic impact of animal agriculture have been observed during the last couple of decades, with significant increases noted in both the absolute value of animal production as well as an increase in the percentage of the total agricultural income in the state that is derived from animal production. Among the many factors that have contributed to the substantial increase in animal production are a favorable economic environment and the adoption of modern production practices by animal producers in the state.

Dramatic improvements in the productivity of animals have been observed during the last half of this century. Growth rate and feed efficiency of meat-producing animals, milk production per cow, number of eggs produced per chicken, etc. have all increased substantially, contributing bountiful quantities of animal protein for our world's population. These increases in production efficiencies have resulted from a fundamental and basic understanding of the genetics and biology of the animals used for human purposes.

Research has clearly shown that our production systems are not close to reaching the biological limits of the animals raised for human use. Additional improvements in the efficiency of production and in the safety and quality of products for human consumption are achievable through further understanding of the basic genetic makeup of our animals and elucidation of the physiological processes within animals. Investigative approaches that involve understanding the animal genome, preserving genetic diversity, and manipulating growth, digestion and reproduction via genetic and biotechnological strategies will contribute to an economically viable animal production industry and a safe, wholesome food supply for the world's population.

Performance Goals

1. Investigate basic biological systems in animals for the purpose of improving the biological efficiency of animals raised for human use.

2. Modulate life processes in animals in order to enhance the productivity of animals, the safety and wholesomeness of animal products, and reduce the environmental impact of animal production via genetic, nutritional, physiological and biochemical manipulation.

3. Investigate the genome of animals and elucidate relationships among the genome, function and structure.

4. Create useful animal models for study of human and animal diseases via genetic and biotechnological manipulation.

Key Program Components
The major research efforts that will be conducted to meet these four stated performance goals are listed in the following key program components. Knowledge gained and knowledge transferred will be the output/outcome indicators for this performance goal.

- Determination of Animal Nutrient Requirements
- Control and Manipulation of the Basic Reproductive Processes in Animals

- Mapping of the Animal Genome, Determination of the Gene or Complex of Genes Responsible for Economically Important Traits

- Enhancement of Animal Productivity and Reduction of Environmental Impact Via Quantitative and Molecular Approaches to Genetic Improvement

- Improvement in the use of Nutrients that Regulate Growth in Animals and Determination of the Factors Controlling the Fat-to-Lean Ratio in Animals

- Basic Studies of the Function and Modulation of Enzymes and Enzymatic Function in Animals

Internal and External Linkages
Numerous linkages will be required to meet the performance goals. Within each key program component, there is an expectation that linkages will be formed internally within the NC State University community, as well as with partners outside the university. Many of these partners will be other scientists both from within and outside of the university working on similar aspects of the programs contained herein.

In order to facilitate the activities involved in this plan of work, linkages will be formed among various departments in the College of Agriculture and Life Sciences at NC State University.
Among these departments are:

Animal Science	Poultry Science
Zoology	Biochemistry
Crop Science	Genetics
Microbiology	

In addition, linkages of faculty in the College of Agriculture and Life Sciences with faculty in the College of Veterinary Medicine and College of Physical and Mathematical Sciences at NC State University will be important to accomplish the key program components. Linkages of investigators at NC State University and with scientists at other universities in the state and nation will also be formed. Among these universities are:

North Carolina A&T State University,
University of North Carolina at Chapel Hill,
Duke University,
Michigan State University,
University of Illinois,
University of Kentucky, and
the University of Georgia.

Linkages with pharmaceutical companies such as Novus International, Pfizer, Ely Lilly are also important to facilitate the research requisite in the plan of work. In addition, knowledge transferability to end users involves partnerships with the animal industries such as:

Murphy Family Farms,
Goldsboro Milling,
Purdue Farms,
Carrol's Foods, and
Smithfield Foods.

Target Audiences
The research conducted in this area has many stakeholders and beneficiaries, including the citizens of North Carolina as well as those who live outside the North Carolina state boundaries, both nationally and internationally. A prioritized list of target audiences is as follows:
Animal producers
Consumers of animal products
Individuals who maintain animals as pets
The agribusiness community
Scientists and researchers
Students

Program Duration
Long-term, 5 years

Allocated Resources
Following are expenditure and commitment data for 1997-1998.

EXPENDITURES

Source	Amount
CSREES Funds	$701,320
USDA-CGCA Funds	$1,001
Other Federal Funds	$371,571
State Appropriation	$4,212,962
Non-Federal Funds	$686,128
Total	$5,972,982

PERSONNEL COMMITMENT

Scientist Years	11.53
Professional Years	15.94
Technical Years	49.6
Clerical Years	3.56
Total	80.60

During the next five years, it would be expected that the total commitment in the animal production systems program will remain approximately $6 million adjusted annually for inflation, and that the personnel commitment will remain consistent with the 1997-98 fiscal year. As conditions change and upon the appropriate recommendations from stakeholders, the budget and personnel inputs for this program may change.

Goal 1, Program Area 3:
Plant Protection Strategies

Subprogram Area 3a:
Forest and Horticultural Crop Protection

Statement of Issue
The aim of the Forest and Horticultural Crop Protection subprogram is to develop technology and biological knowledge that will allow the forestry and horticultural industries as well as urban dwellers to produce fiber, food and ornamentals with less damage from pest insects, mites, nematodes, pathogens and weeds in a more environmentally friendly manner while obtaining an adequate economic return. Research in this subprogram is critical to achievement of the GPRA goals of maintaining and improving an agricultural system that is highly competitive in the global economy and enhancing a safe and secure food and fiber system.

Pest insects, mites, nematodes, pathogens and weeds are organisms that are continuously adapting to new conditions or migrating to different localities. Technology must continually change to meet the altered pest, pathogen and weed pressures and to be compatible with changing production systems. As the human population increases more forest, food and ornamental plants are required. Protection of plants from pests, pathogens and weeds allows producers to maintain productivity or to even increase productivity with less cost to natural resources.

Research, both basic and applied, is necessary to assure that plant protection technology remains efficacious, economical and environmentally sound.

Performance Goals

1. Develop and enhance pest, pathogen and weed management technology for growth and production of forests and horticultural plants for greater enjoyment and profitability in an environmentally sustainable manner.

2. Improve understanding of the ecology and genetics of pest, pathogen and weed populations and their interactions with plants and antagonists for more effective integrated pest management.

3. Incorporate resistance to pests, pathogens and weeds into improved, productive cultivars through classical breeding and biotechnology/genomics.

Key Program Components
North Carolina Agricultural Research Service programs that develop and enhance management technology in an environmentally sound manner include the following general approaches.

- Development of Alternatives to Chemical Pesticides such as Biological Control Agents for Pest Management

- Development of Utilization Methods for the new Pesticides that are Derived from Natural Products that Alter the Hosts' Resistance Mechanisms or that can be Applied in very low Volumes

- Improvement of Models and Decision Assistors that Utilize Cultural Practices, Host Resistance and Physical Environmental Factors to Enhance Pest Management

- Establishment of a Small Fruit Center that has Fostered Regional Dissemination of Best Management Practices

- The Micropropagation Unit is Furnishing Pathogen-Tested, True-to-Type Sweet Potato and Strawberry Cultivars for the Region

Programs that improve understanding of pest ecology and genetics for better IPM practices include the following.

- Improved Understanding of Pest Primary and Secondary Sources as well as Better Knowledge of Pest Short and Long-Range Movement

- Improved Understanding of Pest Biology and Genetics at the Cellular and Molecular Level to Develop Knowledge of the Interactions of Pests with their Hosts and Environment

- Improved Understanding of the Populations of Pests to Better Understand how to Utilize Various Types of Resistance to give Better Pest Management Without loss of Resistance Traits

- Improved Biological Control Tactics to Enhance Integrated Pest Management

The following programs that incorporate resistance into cultivars involve a number of forest and horticultural plants and emphasize numerous aspects of resistance.

- Breeding and Selection of Fraser fir Christmas Tree, Peach, Nectarine, Strawberry, Blueberry, Rubus, Cucurbits, Tomato, Potato, Sweet Potato, Apple and Numerous Ornamental Plants

- Resistance to Insects, Fungi, Viruses, Bacteria, Nematodes and Mites is Being Examined and Incorporated into Multiple Resistant Cultivars

- Increased Knowledge of the Molecular and Genetic Basis of Pest Resistance in Plants, Allowing more Efficient Incorporation of Resistance into Plants by Classic Breeding Methodology

- Biotechnology/Genomics Work that Allows Production of Transgenic Plants with Novel Mechanisms of Resistance

The greatest programmatic effort is expended on understanding the basic biology and ecology of insects, mites, pathogens, nematodes and weeds that affect forest and horticultural plants. This new basic knowledge is then adapted by the clientele stakeholders through the NC Cooperative Extension Service. Most of the new technology for pest management is incorporated into Integrated Pest Management programs to allow growers to operate profitably and in an environmentally sustainable manner.
Pest ecology and genetics are important components of much of the research effort as is biological control. The agricultural industry is producing new transgenic plants as well as new types of pesticides. Significant effort is expended to test these new products and to determine how they perform under grower conditions. Usually pest management practices need to be adapted to utilize these products most effectively. Another major research area involves the study of pest population changes to develop a better understanding of how pests change in relation to management practices, how the life of host resistance to pests can be extended, and how pest management tactics can be utilized to extend their usefulness.

Output Indicators:
Indicators of the effectiveness of North Carolina Agricultural Research Service research include peer reviewed publications that enhance science, other publications that communicate and synthesize information to all levels of society, and local, national and international awards that enhance the morale of scientists. Adoption of research information by extension for pest management programs and communication from stakeholders about the usefulness of research are also output indicators.

Internal and External Linkages
Forty eight North Carolina Agricultural Research Service projects involving 45 principal investigators from seven departments currently address Forest and Horticultural Crops Protection. These projects cover research on numerous approaches to the management of insects, mites, pathogens, nematodes and weeds that affect major forest and vegetable as well as ornamental plants.

There are numerous internal linkages among researchers, both intra- and interdepartmentally. Greater than 75 percent of the projects involve multi-state collaborations through official or unofficial arrangements or through regional or interregional research projects. Among the organizations with which the Research Service has formed linkages are the following.

USDA-ARS laboratories
other universities
USDA-APHIS Programs
Center for Integrated Pest Management
IR-4 Program
North American Disease Forecast Center
NOAA
Small Fruit Center
Micropropagation Unit
North Carolina Crop Improvement Association
North Carolina Foundation Seed Producers Association
North Carolina Biotechnology Commission
many agriculture companies

Target Audiences
The North Carolina Agricultural Research Service has worked closely with the major forest and

horticultural commodity groups for years. There are annual meetings with the commodity groups as well as field days for many commodities such as the Apple Growers Association, Association of Nurserymen, Blueberry Council, Certified Sweet Potato Seed Producers, Christmas Tree Association, Commercial Flower Growers Association, Eastern North Carolina Christmas Tree Growers, Grape Council, Muscadine Grape Growers Association, Greenhouse Vegetable Growers Association, Herb Association, Horticultural Council, Landscape Contractors Association, Master Gardener Association, Peach Growers Society, Pecan Growers Association, Pickle Producers Association, Pine Needle Producers Association, Potato Association, Strawberry Association, Sweetpotato Commission, Tomato Growers Association, Vegetable Growers Association, Watermelon Association and Winegrowers Association.

Research Service scientists enhance the body of science associated with pest management of Forest and Horticultural Plants. Their research also enhances extension faculty in the whole Southeast who adapt the knowledge for use by growers. The farmers, foresters, and general public that grow ornamental plants benefit from Research Service research. The general public also benefits from the quantity and quality of low-cost food and an improved environment as well as quality forest products.

Program Duration
Long-term, 5 years

Allocated Resources
Following are expenditure and commitment data for 1997-98. Similar expenditures and personnel commitments are expected over the next five years.

EXPENDITURES

Source	Amount
CSREES Funds	$553,305
USDA-CGCA Funds	$32,838
Other Federal Funds	$241,849
State Appropriations	$2,823,432
Non-Federal Funds	$623,723
Total	$4,275,147

PERSONNEL COMMITMENT

Scientist Years	11.38
Professional Years	18.23
Technician Years	30.99
Clerical Years	4.46
Total	65.06

Subprogram Area 3b:
Agronomic Crop Protection

Statement of Issue

Agronomic Crop Protection emphasizes the need to develop technology and strategies that will ultimately allow our stakeholders, who are principally producers of our major row crops - corn, soybean, peanut, cotton and small grains - to produce these crops with less economic loss due to the effects of pest insects, mites, nematodes, diseases and weeds. Research accomplishments from this subprogram will be a critical component of our inputs toward achieving our GPRA goal of maintaining and improving an agricultural system that is highly competitive in the global economy.

Despite many advances in technological developments for reducing impacts of pest organisms on these crops, new challenges continually arise. Introductions of new pests into our cropping systems continually occur. In addition, the living pests we are striving to control are continually adapting to overcome the methods we develop to fight them or their impacts. In order for the farmer to be able to produce a crop and obtain sufficient return on investment to live and continue in the farming business, he/she must be able to reduce pest-caused losses to a sub-economic damage level. Thus, there is a continuing and ongoing need to refine old technologies and develop new and novel technologies to maintain an economically competitive edge over these pest organisms. Concurrent with the development and use of pest management strategies is concern over the impact that they may have on the environment. This necessitates that research be conducted to ensure that any potential environmental risks related to pest management strategies be identified and minimized or eliminated.

Performance Goals

1. Develop new and refine existing mechanisms and techniques for managing pests of field crops that are economically feasible for the producers and are environmentally compatible.

2. Improve environmental quality through improved pest management technology.

3. Investigate the genetic basis of key phenotypic characters of pests, their host plants, and their natural enemies, and to use the knowledge gained to manipulate their genetic makeup in ways that will directly or indirectly reduce or eliminate the economic impact of the pests.

Key Program Components

North Carolina Agricultural Research Service programs that include development of new or improved pest management technologies involve the following general approaches.

- Development of Crops that Contain Genetic Resistance to Insects, Nematodes and Disease Organisms

- Control of Pests Using Numerous Alternatives to Chemical Pesticides

- Control of Pests Through Crop Rotation and Other Cultural Techniques

- Development of Pesticide Resistance Management Strategies to Prevent loss of Efficacy of Available Compounds

- Development of Promising new and more Environmentally Compatible Chemical Pesticides

- Development and Refinement of Models for Making Decisions on Pest Management Inputs into Cropping Systems

Environmental quality improvement will be achieved through a number of direct and indirect research approaches including the following.

- Examination and Monitoring of Soil Health in the Presence and Absence of Numerous Pest Management Strategies

- The Development and use of Pesticide-Reducing Technologies

- The Development of Holistic Ecological Pest Management Programs

Genetically based studies to improve pest management technology and practice will involve the following.

- The Development and Wise Deployment of Transgenic Organisms Designed to Alleviate Pest Impact on Field Crops

- Using Molecular Techniques, the Manipulation of Genes in Organisms to Increase or Decrease their Environmental Fitness According to their Role as Host Plants, Pests or Natural Enemies of Pests

- The Molecular Characterization of Plant/Pest Interactions

As a basis for development of economically sound and environmentally compatible pest management systems, considerable effort is placed on research on the basic biology and ecology of pest organisms and the environments in which they occur. Studies of diversity of soil micro flora and micro fauna, for example, are being conducted so that impacts of various pest management tactics and practices on “normal” soil biodiversity can be determined. Basic studies of plant pathogen mode of action are being carried out to learn possible weak points that might be targeted for control purposes. A number of projects are examining epidemiology of plant pathogens and seasonal movements of insects to more precisely predict their occurrence in space and time during the growing season.

By far the greatest programmatic effort is in development of new or improved tools for use in pest management. These include the development of alternatives to broad spectrum pesticides, including development of biological control techniques for weeds, insects, plant pathogens and nematodes; development of crop rotation methods and other cultural techniques for managing specific pest/crop combinations; developing new low-impact chemical pesticides; and development of models that predict precisely when control practices need and do not need to be applied. Heavy emphasis is placed on traditional plant breeding to develop small grain crops, peanut, and other row crop lines that have increased resistance to plant disease, insects and nematode damage. Genetic techniques are also being applied in tobacco, which serves as a model system applicable to other crops to produce resistant cultivars.

Chemical pesticides are being studied for their maximum utility as tools in IPM programs and for determining their mode of action. In some insecticide studies, results are leading to research on new, safer compounds with unique modes of action. Pest resistance to pesticides, whether delivered by traditional means or by transgenic techniques, is a critical issue for growers, and mechanisms by which resistance occurs and by which it can be prevented are being studied.

Molecular and genetic approaches to understanding pest biology, host/pest interactions, development of resistant host plants, and understanding the basis for pest resistance to pesticides are being aggressively pursued. Genomic research is directed at elucidating gene structure, associating gene function with specific regions of genes so that we can manipulate those regions to modify hosts, pests, or natural enemies for pest management purposes. Studies are assessing the economic impacts of use of transgenic row crops.

Concurrent with research on alternative pest management strategies and on chemical pesticide strategies are cost benefit analyses of such strategies relative to reduction of chemical pollution in the environment. Studies are also being conducted to assess the role agricultural pesticides play in biological systems contaminated with them as non-point source pollutants.

Output Indicators:
- Dissemination of research in varying forms, including refereed journal articles, presentations at scientific meetings, farmer field meetings, commodity meetings, news media and others

- Transfer of technology on new and improved IPM tools developed through research to growers and other end users through extension specialists

- Release of genetically superior cultivars and improved germplasm for use by field crop producers and hybridizers

- Acceptance and adoption of new technologies by producers

Internal and External Linkages
Currently, 78 North Carolina Agricultural Research Service research projects involving 56 principal investigators from 10 departments address issues related to agronomic crop protection. Projects involve approaches to management of major insect, disease, nematode and weed pests of corn, small grains, cotton, peanut, soybean and tobacco.

Internal linkages among researchers within and between the nine departments identified with this subprogram area cross all units and to many other units within the university. This is the rule rather than the exception. Greater than 75 percent of the projects involve multi-state collaborations, either through individual arrangements or through official regional or interregional research projects. These external linkages are with researchers from USDA-ARS laboratories, with faculty from many other universities throughout the United States and the world, with USDA-APHIS personnel, and through the Center for Integrated Pest Management, the North American Disease Forecast Center, NOAA, the North Carolina Crop Improvement Association, the North Carolina Foundation Seed Producers Association, and scientists from a large number of agricultural product companies.

Target Audiences
The North Carolina Agricultural Research Service has worked closely with the principal row-crop commodity groups for many years. Annual meetings are held with state soybean producer, small grain producer, corn producer, peanut producer, cotton producer and tobacco producer associations. At these meetings, producers are given written and oral reports of the research being funded by federal, state and private funds. They provide input at these meetings on their needs and concerns and help shape our specific research agendas. This has been an excellent system and has promoted a feeling of partnership between our growers and our researchers. Other important stakeholders are the industries who produce products for agricultural pest control and management. Our students, pest management scientists worldwide, and numerous non-governmental organizations are also important stakeholders and clientele.

The audiences for this work are other research scientists who will build on research results obtained, extension faculty who will transfer the technologies developed to the farmer, the farmer who will ultimately benefit economically from the research discoveries, and the general public who will receive quality, low-cost food and an improved living environment.

Program Duration
Long-term, 5 years

Allocated Resources
Following are expenditure and commitment data for 1997-98. Similar expenditures and personnel commitments are expected over the next five years.

EXPENDITURES

Source	Amount
CSREES Funds	$847,212
USDA-CGCA Funds	$309,612
Other Federal Funds	$999,446
State Appropriation	$4,030,299
Non-Federal Funds	$1,035,418
Total	$7,221,987

PERSONNEL COMMITMENT

Scientist Years	17.34
Professional Years	28.33
Technician Years	38.42
Clerical Years	11.39
Total	95.48

Goal 1, Program Area 4:
Animal Diseases and Animal Health

Statement of Issue
North Carolina's food-animal industries produce approximately 56 percent of the state's annual farm gate income. A number of distinct sub-industries are included, namely for the production of broiler chickens, turkeys, egg production chickens, game birds (*i.e.* ducks, pheasants, bobwhite quail), swine, dairy, beef, dairy goats and aquaculture. Each sub-industry is economically significant in its own right, but collectively these industries are extremely important to the overall economic well being of North Carolina.

Production methods, especially for the swine and poultry industries and to a lesser degree for the dairy industry, have undergone major changes over the past four to five decades. In the first half of the 20th century, animals were produced in small numbers on single family farms. In the second half, flock and herd sizes have rapidly increased to the point where in the new millennium the vast majority of food animals will be produced in very large herds and flocks on a contractual basis under the control of very large vertically integrated companies. The concentration of animal production has resulted in increased risks of disease exposure and disease outbreaks and has resulted in much greater attention to preventative medicine and methods to minimize pathogen exposure (*i.e.*, biosecurity). These changes in the scale of animal production have also caused changes in the general approach to animal health, *i.e.*, from the treatment of single animals to the treatment of large groups (*i.e.*, herds and flocks) of animals. Numerous vaccines, antibiotics and other preventative medications have been developed and have greatly improved producers' abilities to maintain large concentrations of animals. Nevertheless, new forms of pathogenic organisms and new disease conditions from new forms of known and even from unknown pathogenic agents continue to challenge our food animal industries.

The concentration of animal production in limited geographical areas also poses major challenges for the food-animal industries in terms of maintaining a healthy and sustainable environment. The production of extremely large amounts of animal by-products (*i.e*., manure, litter, mortalities, offal and feathers) and the odors and pests associated with the production and degradation of some of those by-products constitute one of the major challenges to the food-animal industries. Methods must be developed to handle and recycle these by-products in a manner that is not only environmentally safe but economically feasible and socially acceptable if present production methods and practices are to remain sustainable. Effective best management practices must also be developed for the control of the pests and odors associated with the production of the industries by-products.

Performance Goals

1. Improve overall animal health and performance through methods that reduce the incidence and/or severity of diseases caused by pathogenic agents and/or other environmental factors for all of North Carolina's food-animal industries.

2. Develop environmentally safe, economically realistic and socially acceptable methods for the handling and recycling of the by-products of the food-animal industries.

3. Develop effective, safe and acceptable practices for the control of odor and pests associated with food-animal production.

Key Program Components
North Carolina Agricultural Research Service programs for improving the health and reducing the

incidence of diseases affecting North Carolina livestock, poultry and aquaculture industries will involve:

- control and/or elimination of insect pathogen vectors and external parasites;
- control or eradication of bacterial, viral and fungal pathogens;
- control or elimination of internal parasites;
- identification and control of mold-based toxins in animal feeds; and
- reduction and/or elimination of pathogens such as *Salmonella, Campylobacter* and *Listeria* that can be transmitted to humans through animal products.

Environmental protection and sustainability for North Carolina's food-animal industries will involve:

- development of economically sound and effective practices that reduce the environmental impacts (*i.e.* on air, ground and surface water quality) of food-animal production;
- development of economically viable and socially acceptable value-added products from animal by-products that will help move those by-products out of the animal producing areas;
- development of methods for reducing the odors associated with animal production; and
- control of nuisance pests (*e.g.*, flies, litter beetles and cockroaches) associated with the production of animal by-products.

Currently more than 40 research projects involving 35 NC State University principal investigators are included under this general area of research.

Input from the Departments of Animal Science and Poultry Science Advisory Committees, from the College of Veterinary Medicine Advisory Committee, and from discussions with various animal commodity groups at the state and national level have indicated that animal health and the environmental concerns surrounding the food-animal industries are high priority issues. The following general approaches will be utilized to address the major components of these issues.

- *Understanding the Basic Biological Mechanism(s) of Pathogenesis of Known Animal Pathogens and of Animal Food Borne Human Pathogens*

Work continues in several laboratories in the colleges of Agriculture and Life Sciences and Veterinary Medicine on determining the basic genetic control mechanisms for and the physiological effects of animal pathogens (*e.g., Bordetella avium, Escherichia coli, Staphylococcus aureus, Salmonella sp., Campylobacter jejuni, Listeria monocytogenes,* the putative small viral agents for Poult Enteritis and Mortality Syndrome in Turkeys (PEMS), Rotavirus Enteritis in Pigs, *etc.*). Understanding of the basic genetic mechanisms of pathogenic agents that affect the onset and severity of a disease should help the industry with the development of Best Management Practices for the prevention and/or amelioration of that disease as well as provide insight into potential avenues for the development of novel vaccines to

prevent the disease.

For example, research is underway that is aimed at understanding the genetics and cell biology of *Salmonella* and pathogenic *E. coli* infections. This work is directed at gaining a better understanding of how those pathogens resist and overcome the host's immune system. A combination of classical genetics and current molecular techniques are being used to dissect the virulence of *Salmonella* and to use this knowledge to express pathogenic *E. coli* genes in Salmonella vaccine strains. Constructed mutations in genes have been shown to profoundly attenuate the ability of *Salmonella* to cause the disease in food-producing animals. Use of mutants as a live vaccine to express foreign antigens from pathogenic *E. coli* is also being pursued. The primary goal of this type of research is to produce safe, effective, live vaccines that will ultimately prevent long term carriage of food-borne pathogens in food-producing animals. Vaccination of cattle, swine and poultry with such constructed mutant strains will prevent the colonization of pathogenic *Salmonella* and/or *E. coli* in their intestinal tracts. Ultimately, reducing the presence of such pathogens in our food-animals should result in microbiologically safer food.
Outcome indicators:
- Number of new Genetic/Cellular Mechanisms Identified Related to Pathogenicity
- Number of Mutant Vaccine Strains Produced
- Number of Best Management Practices Developed for the Prevention and/or Control of one or more Animal Diseases

- *Elucidation of the Pathogenic Agent(s) Associated with Diseases of Unknown Origin*

Diseases of livestock and poultry continue to arise for which there is no known pathogenic or environmental cause. The causative agent(s) for most enteric or diarrheal diseases in livestock and poultry species are unknown. PEMS is a good example of such a disease that for the past 7 or 8 years has caused major economic losses to the North Carolina turkey industry. Considerable time and effort has been expended by faculty in the colleges of Agriculture and Life Sciences and Veterinary Medicine over the past few years to identify the causative agent(s) for this disease. Two putative viruses have recently been identified, and are now being characterized. Work on PEMS and other diseases with unknown agents will continue as the need arises and funding support is available.
Outcome indicators:
- Number of new Pathogens Identified
- Number of new Pathogens Characterized

- *Development of New, Improved and/or Novel Vaccines and Therapeutics for the Prevention and Control of Food-Animal Diseases*

Biotech methodologies are being used to develop novel vaccines from known pathogens. Work aimed at developing an understanding of the basic biological mechanisms of pathogenesis should lead to the development of strategies for the production of novel vaccines and therapeutics.
Outcome indicators:
- Number of Novel Potential Vaccine Methods Developed
- Number of Novel Potential Vaccines Developed and Produced

- *Integrated Pest Management for Food-Animal Pests*

Pests associated with confined poultry and livestock include muscoid flies (house fly, and lesser house fly), biting flies, darkling beetles, mites, and cockroaches. Integrated Pest Management (IPM) includes a multidisciplinary approach to the management of these pests, among these are sanitation, cultural control,

biological control and chemical control. Successful sanitation programs effectively reduce the habitat conducive to the growth and development of the pest. Cultural control relies on the manipulation of the habitat through alternative litter materials, moisture management and trapping technology to reduce the pest population. Although significant reductions in pest populations occur, some complete development. Predators and parasitoids searching for hosts clean up those that were missed.

Poultry and livestock are considered minor use groups by the pesticide industry. Consequently, few companies take the time and effort to register pesticides for animal use, limiting the pesticide options available to the producer. Fortunately, IPM has developed strategies that allow the conservation of effective pesticides for use through a last resort strategy. Chemical controls are used judiciously, thus protecting the beneficial predators and parasites, delaying the onset of resistance, and reducing pesticides in our foods. Our goals are: 1) to focus on the laboratory and field evaluation of a variety of biological control agents, parasitic and pathogenic, for the control of poultry and livestock pests, 2) to develop alternatives to chemically based pest management strategies, and 3) to introduce the use of promising agents for integration into pest management plans through research and extension publications and meetings.
Outcome indicators:
- Number of Nonchemical Alternative Management Strategies Developed for Poultry and Livestock Pests
- Number of Alternative Pest Management Agents Introduced to the Industry

- *Development and Improvement of Methods for Identifying and Controlling Feed Based Toxins That Reduce Food-Animal Performance*

Mycotoxins and Fusarium toxins in feed grains continue to cause feed refusal and performance problems when animals receive them in their diets. Scientists working with the College of Agriculture and Life Sciences Mycotoxin Laboratory continue to work with the food-animal industries to monitor the levels of the various toxins in feedstuffs. They continue to explore the development of new rapid, accurate, low cost analysis and sampling methods that can be used to assess the levels of such toxins in feed grains. Novel approaches for binding such toxins (*e.g.*, with the addition of inert substances such as clay to the diet) so that they will not be absorbed as they pass through the animal are also being explored.
Outcome indicators:
- Number of Mycotoxin Analysis Methods Developed and/or Improved
- Number of Mycotoxin Sampling and Amelioration Methods Developed and/or Improved
- Number of Mycotoxin Binding Techniques Developed and/or Improved

- *Improving the Basic Understanding of Immune Function and the Interrelationships of Genetic and Environmental Factors Affecting Immune Function and Animal Performance*

The continued health of any animal is dependent upon its genetic ability to withstand pathogenic challenges to its immune system. Thus, a very basic understanding of the immune system, how it develops, how it functions, and how it withstands genetic and environmental insults is critical to the maintenance of good animal health. The colleges of Agriculture and Life Sciences and Veterinary Medicine have a very strong interdepartmental immunology program involving research on both humoral and cellular immune effector functions. Macrophage development and function has been and will continue to be a major part of this research. Macrophages are, of course, often considered to be the first line of defense against pathogens. On a more applied basis, the production and role of various types of cytokines is another basic area of immune function research. At a more applied level, studies of the effects of different forms of nutrients in

the diet (*e.g.*, organic versus inorganic forms of minerals) on immune function are also yielding interesting approaches to ways to improve immune response. These general types of studies will continue.
Outcome indicators:
- Number of new Immune Effector Functions Discovered and Described
- Number of Roles of Cytokines Discovered and Described
- Number of Nutritional Strategies Developed for the Improvement of Immune Functions

- *Use of Probiotics to Competitively Exclude Pathogenic Organisms From Food-Animals*

The ability of certain types of naturally occurring gut microflora if introduced into the intestinal tract of the neonate to competitively exclude some types of pathogens has been known for many years. Unfortunately, many of the competitive exclusion agents are destroyed by the use of feed-grade antibiotics, so in order to take advantage of probiotics in animals receiving low levels of antibiotics, the probiotics must be supplied to the animals on a continuous basis. The expense and problems involved in doing so have prevented probiotics from being used on an extensive basis in the North Carolina and U.S. animal industries. In Europe, however, with the banning over the past few years of the use of feed-grade antibiotics, probiotics has taken on a much larger role.

Several College of Agriculture and Life Sciences faculty members have been involved for a number of years with research on probiotics for food-animal species. Their research has focused on the bacterial genus and species to be used as a probiotic, on the methods and timing of exposure, and on the effects of the probiotic on the performance of the receiving animals. Probiotic research should be expanded if the use of feed-grade antibiotics is also banned in the U.S. market, which appears likely at some point in the future. In the meantime, basic probiotic research will continue.
Outcome indicators:
- Number of Novel Probiotics Developed and Tested for the Replacement of Feed-Grade Antibiotics
- Adoption Rate for use of Probiotics by the Industry

- *Measurement of the Environmental Impact of Food-Animal Production on Ground and Surface Waters*

NC State University and the College of Agriculture and Life Sciences have a long history of being involved in research and extension efforts related to improved methods of animal waste management and of protecting and improving ground and surface water quality. In recent years, the college developed its Animal and Poultry Waste Management Center, which is aimed at the development of new technologies for the recycling of animal by-products into value-added co-products for the animal industries. These co-products must not only be economically feasible, they must also be socially and aesthetically acceptable. The center has also been involved with the demonstration and testing of numerous commercially available waste remediation technologies in order to see if they could be adapted for the animal industries. A novel approach, *i.e.*, using the naturally occurring radioisotopes of nitrogen, is being developed and tested as a accurate method for the determination of non-point sources of pollution. Through fiscal year 1998-99, nearly 100 different research and/or demonstration projects have been sponsored by the Animal and Poultry Waste Management Center, and projects of this type will likely continue to expand. Most of the center's projects, although generally not directly involved with ground and surface water studies, have the potential of reducing the amounts of nutrients ending up in such waters. Most are multi-disciplinary in nature, and a significant number of them require and involve multi-state participation.
Outcome indicators:
- Number of new Technologies Developed with Potential for Reducing Impacts on Ground and Surface

Water Pollution from Animal Wastes

▸ *Measuring the Environmental Impact of Food-Animal Production on Air Quality and Odor*
College of Agriculture and Life Sciences faculty involved with the Animal and Poultry Waste Management Center have also been involved with the testing of commercially available odor control products. The development of specific technologies such as biofilters, air washing walls, windbreak walls, *etc*., to reduce and eliminate odors has been another major area of research. The development of an electronic nose to measure odor is one of the components that will continue to be developed and refined. Due to the intense public pressure, especially related to the odors produced by swine operations, this type of research will continue and expand during the foreseeable future.
Outcome indicators:
▸ Number of Technologies Developed for Reducing Odors
▸ Number of Industry Products Identified and Tested that have Significant Impact on Reducing Animal Odors
▸ Number of Technologies Developed that Improve the Ability to Accurately Measure Odor Levels

▸ *Development of Value-Added Products From Food-Animal By-Products*
Several College of Agriculture and Life Sciences faculty are deeply involved in the development of alternative uses for animal wastes. These alternative uses not only have the prospective of reducing and/or eliminating some of the problems associated with these by-products, but they will likely increase the value of the waste product to the point where it will be economically feasible to move it out of the production area. Projects on the recycling of separated manure solids, animal mortalites, and manures and litters are underway and several show great promise for changing what has traditionally been considered a waste product into something that is far more valuable. These types of studies will be continued and expanded.
Outcome indicators:
▸ Number of Value-Added Products Developed from Animal By-Products

Internal and External Linkages
Internally, subprogram area 4 activities involve faculty from at least 12 different departments in the College of Agriculture and Life Sciences. Faculty from the following departments are activity in this area.

Animal Science	Agricultural and Resource Economics
Biological and Agricultural Engineering	Crop Science
Entomology	Food Science
Genetics	Microbiology
Poultry Science	Soil Science
Statistics	Zoology

Faculty in the colleges of Forestry (Department of Forestry), Physical and Mathematical Sciences (Department of Earth, Marine and Atmospheric Sciences), and Veterinary Medicine (departments of Food Animal and Equine Medicine and Microbiology, Pathology and Parasitology) are also involved in this area. Most projects are multidisciplinary in nature, and involve several faculty from different departments and/or universities. Some projects also involve industry personnel as collaborators.

Externally, this area involves numerous linkages. The College of Agriculture and Life Science's Animal and Poultry Waste Management Center, under which most of the environmental studies are conducted, has seven industrial companies and eight other Universities on its board of directors. NC State was one of

the primary instigators of a multi-state consortium for animal waste management research that now includes the states of North Carolina, Iowa, Missouri, Oklahoma, Indiana and Minnesota. The College of Veterinary Medicine has received a major Fund for Rural America grant that includes several universities that are jointly working on the epidemiology and biosecurity related to poultry diseases. International linkages have been formed with the following universities.

Applied Poultry Research Centre in Beekbergen, the Netherlands
National Agricultural University at Wageningen, the Netherlands
Università degli Studi di Bologna, Bologna, Italy
National Taiwan University, Taipei, Taiwan
University of Sydney, Sydney, Australia

A number of the College of Agriculture and Life Sciences faculty are working with other scientists from around the United States through several Regional Research projects related to animal waste management. New linkages will continue to be developed with industry and other university groups.

Target Audiences
The primary audience includes all of the food-animal producing industries in North Carolina. Other beneficiaries will include segments of those industries outside of North Carolina, both nationally and internationally, as well as the general public or consumers. Students studying to become involved with the animal industries, either as managers or veterinarians, will be among the direct recipients of these technologies. Allied industry companies will also be direct beneficiaries of some of these technologies.

Program Duration
Long-term, 5-plus years

Allocated Resources
Following are expenditures and commitment data for the 1997-98 year.

EXPENDITURES

Source	Amount
CSREES Funds	$359,995
USDA-CGCA Funds	$25,356
Other Federal Funds	$284,192
State Appropriations	$1,999,429
Non-Federal Funds	$536,215
Total	$3,205,187

PERSONNEL COMMITMENT

Scientist Years	8.81
Professional Years	7.68
Technician Years	19.60
Clerical Years	4.45
Total	40.52

It is anticipated that future funding and human resource allocations for subprogram Area 4 will continue with roughly the same emphasis as shown above during the period of this plan of work (5 years). Significant changes may take place if a major new disease should occur or if use of feed-grade antibiotics should occur. Such changes would be made based on input from scientists and stakeholders.

Goal 1, Program Area 5:

Farm Business Management, Economics and Marketing

Statement of Issue

Faculty with projects in seven academic departments conduct research in farm business management, economics and marketing that discover and disseminate information important to a variety of agricultural-related businesses and to citizens of North Carolina. Sound economic decision-making behavior by a host of different agents, which include farmers, suppliers of inputs and processors of output, policy makers, wholesalers, retailers, distributors and others, is at the center of the analysis within this area. The factors that affect risk management, including production, price, and marketing risk, of North Carolina commodities are identified and quantified to the extent possible and incorporated in policy and decision-making recommendations. Other policy analyses include quantifying the impacts of international trade agreements on production and consumption activities locally, regionally and globally.

Performance Goals

1. Improve the economic decision-making abilities of the various agents who engage in the production, processing, marketing, and management of agricultural products (food, fiber, forestry and ornamentals) grown and/or marketed in North Carolina.

2. Increase the readily available decision making information to participants in the production and marketing process.

3. Identify socially optimal environmental enhancement (or degradation) and environmental/health risks and the least cost policies and regulations for achieving them.

Key Program Components

Management, economics and marketing have multiple components, with only the area of supply, demand, and price analysis (crop and animal products) representing a significant share of the total effort (measured by time). This component represents 42 percent of the total time effort and 34 percent of the total funds committed to this topic. In total, 12 very diverse categories are identified by College of Agriculture and Life Sciences research faculty, including farm business management, marketing of agricultural products, market performance and several categories in international economics (combining four of these international categories results in 20 percent of the total time effort). Twenty-one researchers from seven disciplines have allocated a portion of their time to these different categories.

The large effort related to supply and demand of crop and animal products is reasonable given the diverse set of commodities produced and processed in North Carolina. It is in this area that researchers attempt to discover new information that helps producers, consumers, and all agents throughout the food and fiber chain make better informed decisions. Considerable effort relates to the managing of production and

marketing risk. As income protection to farmers from federal farm programs declines, managing risk will become more important to firms engaged in agricultural commodity production and suppliers of inputs to these firms.

In a related area, researchers will endeavor to discover ways to improve the efficiency and profitability to parties engaged in contractual agreements of production. Transferring risk (production, price or marketing) to those agents who can exercise control in the decisions should lead to improved contractual arrangements. Other efforts to analyze market performance will include investigations of technological and social factors that influence the food system.

Other components include efforts to improve sampling techniques to detect mycotoxins to develop innovative techniques to improve profitability in seafood processing and packaging.

International research efforts will concentrate on technical assistance for soil management and on policy factors that increase or inhibit international trade.

Internal and External Linkages
Multi-state:
S-278, Food demand and consumer behavior, S-222, Fruit and vegetable supply chain management, innovations, and competitiveness

Institutional:
Michigan State University
Iowa State University
University of Tennessee
University of California-Davis
Cornell University
Clemson University
University of Florida
Virginia Tech University
University of Illinois
Ohio State University

Target Audiences
Direct targets are those agents/firms who engage in the production and marketing activities addressed in these research efforts. These include farmers, suppliers of inputs, handlers of outputs, international agencies, policy makers and others. Ultimately, the general public as consumers are the benefactors of nearly all research performed in this area through reduced food prices, increased food choices and a more efficient and effective marketing system. Professional research peers as well as educators (teachers and extension service personnel) receive the information generated by these research efforts.

Program Duration
Long-term, 5 years

Allocated Resources
Following are expenditures and commitment data for 1997-98.

EXPENDITURES

Source	Amount
CREES Funds	$197,699
USDA-CGCA Funds	$45,562
Other Federal Funds	$827,975
State Appropriations	$1,015,521
Non-Federal Funds	$106,650
Total	$2,193,407

PERSONNEL COMMITMENT

Scientist Years	3.73
Professional Years	6.20
Technician Years	3.95
Clerical Years	1.78
Total	15.66

Farm business management, economics and marketing includes projects from 12 of the 17 categories, including farm business management; improvement of grades and standards—crop and animal products; efficiency in marketing agricultural products and production inputs; supply, demand, and price analysis; competitive interrelationships in agriculture; development of domestic markets for farm products; performance of marketing systems; group action and market power; improvement in agricultural statistics; foreign market development; technical assistance to developing countries; and product development and marketing for foreign markets.

A proposed effort to start a Center for Resource and Environmental Policy, which will give rise to better informed decisions by policy makers and other entrepreneurs about the interaction of the environment and profitable agriculture, will require core faculty time, research assistantships, tuition remission, technical support, and additional operating funds. Farm management will become increasingly responsive to more stringent environmental regulations regarding off-farm effects on water quality, air, and health risks. Science from multiple disciplines will provide significant input into economic models in this research.

Goal 1, Program Area 6:
Product Development

Statement of Issue
As global competitiveness and consumer concern about food safety, nutrition, value-added products and the environment grow, North Carolina is examining how new value and new products can be developed from agricultural raw products for economic growth.

North Carolina is experiencing a period of rapid growth and social and economic change. Farms are decreasing in number and increasing in size, and the overall trend is toward vertical integration. Technology is rapidly changing. Consumers are more concerned about food safety, nutrition, value-added products and the environment, and their perception of agricultural chemicals, biotechnology and other

technology is becoming more negative. The public is demanding safe, affordable food in an era of increasingly stringent regulations.
An expanding globalization of agriculture and the economy of North Carolina is forcing restructuring of basic agricultural industries and institutions, requiring more emphasis on integration of global concepts into value-added products.

Performance Goals

1. Development of new and improved animal and fruit and vegetable products, reduction of waste through development of by-products. It is envisioned that new products and/or processes will be adopted by industry leading to economic expansion by way of domestic and international sales of North Carolina and other U.S. value-enhanced agricultural products. Single-event economic impact can be equated to a $20 million or greater increase in sales.

2. Creation of linkages in regions, institutions, commodity groups and in disciplines in an effort to better address the product development challenges facing North Carolina.

Key Program Components
Value-enhanced research is being performed on both plant and animal agricultural products. Plants being studied include cucumbers, sweet potatoes, small fruits (strawberries, blueberries, etc.), peanuts and soybeans. Poultry, swine, and seafood tissue research is strong as well as animal products (dairy, egg, and fish oil). Process research leading to new products include continuous flow thermal, fermentations, frying, nonthermal bioprocessing, and enzyme enhanced.

Thirty-nine projects may be included in the product development area. Represented within those projects are research efforts from six academic departments. Contributing to new economic opportunities in protein utilization is research focused on developing a better understanding of how macromolecules form structures. Six systems (sols, emulsions, foams, polymer gels, particulate gels and multi-component gels) are the focus of attention, using polymer and colloidal-based models. The primary goal is to create understanding that will lead to product development in the meats, dairy, confectionery, and/or snack foods area.

Preventing process alterations due to bioprocess changes is extremely important. Industrial fermentations of growth and metabolic activities of bacterial cultures are vital to the value-added bioprocessing of foods, proteins, enzymes, and chemicals. Most of these processes are susceptible to bacteriophage infection resulting in devastating product losses and raw material spoilage. It is a goal of this research to define, characterize, and exploit phage promoters that are triggered during different stages of the phage infection. It is also a goal to better understand, leading to control of the genetic routes through which phage evolve and retaliate against host-encoded defense systems. This work typifies the interdiscipline approach to problem-solving utilizing microbiology, genetics, and molecular biology.

Several projects in the product development area focus on waste reduction and by-product utilization. In one research area, bioconversion of feather keratin to a nutrient resource is being carried out. Feather degrading bacterium Bacillus licheniformis has been shown to produce crude keratinase. Keratinase treated feather meal can then be used as a protein source in broiler chick diets, competing well with

soybean meal and utilizing a previously difficult to-dispose-of waste. In another area, safe and economical methods are being developed for conversion of animal mortalities into value-added products for recycling as feed ingredients for the food-animal aquaculture and pet food industries.

It is envisioned that a new effort in agricultural tissue engineering will focus on cell generation to produce bioproducts. These reactor grown tissues will be harvested at production rates with high yields, low waste, and be disease and pathogen free.

Internal and External Linkages
Multi-State:
North Central Regional Project NC-136 (Alabama, California, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Michigan., Minnesota, Mississippi., Nebraska, New Jersey, New York, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, Texas, Washington and Wisconsin)

Southeast Dairy Food Research Center (North Carolina, Mississippi)

Center for Aseptic Processing and Packaging Studies (CAPPS) (North Carolina, Ohio, California, in conjunction with the National Science Foundation and 15 industrial members

Multi-Institutional; Multi-Departmental:
Animal and Poultry Waste Management Center

North Carolina Department of Agriculture and Consumer Services Research Stations

NC State University Meat Processing Laboratory (Food Science, Poultry Science, Animal Science, and Biological and Agricultural Engineering departments in the College of Agriculture and Life Sciences; College of Veterinary Medicine)

Current efforts are focused on developing a regional poultry center comprising North Carolina, South Carolina, Delaware, Maryland, Virginia, and West Virginia. This center would encourage coordination of teaching, research, and extension efforts in order to strengthen poultry-related programs over the entire region.

Target Audiences
The ultimate audience is consumers who desire value-enhanced, convenient, safe food and non-food products. Intermediate audiences (stakeholders) include industry, extension agents, the university research community and the North Carolina Department of Agriculture and Consumer Services

Program Duration
Long-term, 5 years

Allocated Resources
Following are expenditure and commitment data for 1997-98.

EXPENDITURES

Source	Amount

CSREES Funds	$266,593
USDA-CGCA Funds	$117,806
Other Federal Funds	$666,063
State Appropriations	$1,956,516
Non-Federal Funds	$708,947
Total	$3,715,925

PERSONNEL COMMITMENT

Scientist Years	11.67
Professional Years	26.59
Technician Years	10.06
Clerical Years	6.92
Total	55.24

Product development includes new and improved fruit and vegetable products and byproducts; food products from field crops; feed, textile, and industrial products from field crops; meat, milk, eggs, and other animal food products; and non-food animal products. It is envisioned that new product development efforts, taking advantage of novel techniques (*i.e.*, tissue engineering) will require new investment. Currently, no program focuses on tissue engineering. Resources should support this effort at a minimum of 2.0 scientist years.

National Goal 2:
A Safe and Secure Food and Fiber System

Program Area 7:
Food and Fiber Processing, Safety and Quality

Statement of Issue

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 *e. coli, listeria* and other potentially life threatening microbiological contaminants as well as pesticides, hormones, etc. requires redoubled efforts to guarantee a safe and worry-free supply of wholesome food.

To address all aspects of safety and quality in the food and fiber system, research must be carried out at the production level, the harvest and marketing level, the processing level and the preparation level. Additionally, with the diverse production system found in North Carolina, the research must be conducted over a broad spectrum of commodities and situations.

Performance Goals

This program area is primarily focused on identifying problems and improving processes in food and fiber production in order to improve safety and quality. Specific goals are to:

1. Identify problems and provide solutions to quality maintenance in storing and marketing fruits and vegetables, field crops and animal products;

2. Ensure that food products are free from toxic contaminants; and

3. Protect food and feed supplies from harmful microorganisms and naturally occurring toxins.

Key Program Components

Research efforts in the general areas of physiology, postharvest handling, storage/processing, and packaging are being conducted in the departments of Food Science, Crop Science, Horticultural Science, Biological and Agricultural Engineering, Entomology and Biochemistry. Research programs on the risks associated with and control and removal of contaminants in food and feed, including toxic residues from production, microorganisms and natural toxins, are ongoing in the departments of Animal Science, Agricultural and Resource Economics, Biological and Agricultural Engineering, Food Science, Microbiology and Plant Pathology.

Thirty-one state and Hatch projects make up Area 7. Scientists from 11 departments within the College of Agriculture and Life Sciences are involved in five research program areas. Technology for HAACP applications in North Carolina's seafood industry, improved meat processing technologies, surface sterilization of microbiological contamination, insect damage to economically important crops in storage,

and safer packaging systems are but a few of the efforts in this program area.

Internal and External Linkages
This program involves half of the Agriculture and Life Science departments at NC State. Many of the projects are multidisciplinary and multidepartmental. A strong multistate component also exists, with four regional projects (NE-103, NE-179, S-263, and S-284). These regional efforts involve most of the states in the Northeast, the South, and many in the Midwest. The Center for Aseptic Processing and Packaging Studies, the NC State Seafood Lab (at Morehead City), and the NC State Meat Processing Lab also provide linkages with other universities, industry partners, producers and regulators.

Target Audiences
Consumers are the primary beneficiaries of this research and development; however, stakeholders include producers, processors, other scientists, agency personnel (NCDA, USDA, FDA), extension agents, regulators and students.

Program Duration
Long-term, 5 years

Allocated Resources
Following are expenditure and commitment data for 1997-98. Similar expenditures and personnel commitments are expected over the next five years.

EXPENDITURES

Source	Amount
CSREES Funds	$266,683
USDA-CGCA Funds	$57,146
Other Federal Funds	$96,623
State Appropriation	$905,938
Non-Federal Funds	$204,711
Total	$1,531,101

PERSONNEL COMMITMENT

Scientist Years	5.67
Professional Years	4.90
Technician Years	7.22
Clerical Years	4.27
Total	22.06

The largest efforts (as a percent of expenditures) include: new poultry product processing technologies (11.9 percent), management of insects that damage stored agricultural products (8.7 percent), detecting pathogenic organisms in food (8.5 percent), technologies to retain or improve quality during production and postharvest handling of fruits, vegetables and nuts (8.2 percent), aseptic processing and packaging (6.3 percent), meat quality improvement (5.1 percent), and quality flavor development in peanuts (5.0 percent).

National Goal 3:
A Healthy, Well-Nourished Population

Program Area 8:
Human Nutrition and Human Health

Statement of Issue
Projects in 10 academic departments focus on human nutrition and health issues significant to the well-being of the citizens of North Carolina and to the agricultural economy of the state. Disease prevention and health promotion are at the heart of research within this area. Nutrient availability and absorption coupled with food choices, habits, and consumption are focused issues. Nutrition and linkages between nutrition and disease prevention are issues. Health and safety of citizens are critical, as methods to reduce hazards are examined.

Performance Goals

1. Human nutrition studies are cause and effect. Key program components listed will be measured and results used as output indicators. Human health and hazard reduction research will be monitored as to adoption by the private sector and by associate research labs. Agricultural economic indicators will provide output indicators for work in the food choices, habits and consumption research areas.

2. Focus will be given to food safety issues as related to overall consumer health and well-being. Adequate resources to address microbial hazards within our food system will be sought.

Key Program Components
Human nutrition research accounts for 62.5 percent of the manpower years within this program area. Human nutrition projects study weight loss programs for post-partum women; Vitamin C supplementation in young smokers as to a beneficial effect on LDL oxidizability, plasma lipid perodidation and neutrophil function; serum lipid, glucose, insulin and chromium profiles of growing pigs fed high-fat diets using milk proteins with and without chromium; interactions of dietary flavonoids with nutrient antioxidants; bioavailability and absorption of carotenoids from foods; impact of Vitamin C on phagocyte function in aging; and the study of how dietary lipids influence adipocyte growth and development of obesity. Human health is being aided by studies focusing on early disease detection (new coronary heart disease risk assessment method); mechanism comparison between animal and human infections; pathogenesis of salmonella; and vaccine development using computer assisted electron microscopy tomography. Agricultural economics are being examined by better understanding consumer preference relative to real and perceived health benefits. Hazard reductions are being realized by development of textile materials for environmental compatibility; by studying the effects of DNA methylation on mammalian limb development; and by development of insect specific target systems for infestation control.

Seventeen projects make up Area 8, Human Nutrition and Human Health. Represented within those projects are research efforts from 10 academic departments. Contributing to this area is the increasing evidence that flavonoids play a role in disease prevention and possibly health promotion. The flavonoids

are a diverse group of plant secondary metabolites and constitute one of the largest groups of naturally occurring phenols. Potential health effects include anticarcinogenic, anti-inflammatory, anti-allergenic, anti-thrombic, as well as anti-hypertension, anti-arrhythmic, anti-oxidant and hypocholesterolemic. Efforts are focused on understanding interactions of flavonoids with nutrient antioxidants, in vitro and in vivo.

Relative levels of plasma LDL, VLDL, and HDL in blood can now be determined using Nuclear Magnetic Resonance Spectroscopy. This technology also classifies the lipid vesicle according to size. Risk factors have been shown to be related to vesicle size. This developing technology may revolutionize the process of blood analysis and disease risk determination. A technology for producing vaccines against membrane containing viruses which are vectored by insects has been developed. This technology will work for any membrane containing virus which can replicate or be made to replicate in insect cells. This technology will be exploited to produce vaccines against a variety of human and animal pathogens.

The bioavailability and absorption of carotenoids from foods are being examined. In addition to the well established role of β-carotene as a precursor of vitamin A, a number of the carotenoids present in the human diet possess antioxidant and anticarcinogenic activities. Moreover, they appear to enhance immunocompetence and cell-cell communication by vitamin A-independent mechanisms. Little information is available about the influences of food processing and other components of the diet on the release of these health-promoting compounds from the food matrix and the subsequent absorption, metabolism and molecular functions of the pigments and their metabolites. Model systems being employed assess chemical modifications. Model systems assess chemical modifications of carotenoids during the digestion process, intestinal cell metabolism of carotenoids, and the bioavailability of carotenoids from diverse foods.

Two projects are related to the epidemic of obesity in the U.S. The first is directed towards evaluating the possible impact of weight reduction during lactation on maternal health and infant growth. Failure to lose weight gained during pregnancy within the first year after delivering a child represents a major risk for obesity. Breast-feeding mothers have been discouraged from attempting to lose gained weight for fear that the growth and development of the infant would be jeopardized. Results from this important study clearly show that controlled maternal weight loss (about 1 pound per week) by reducing energy intake and increasing physical activity has no adverse effect on the growth and general health of the breast-feeding infant. From a more basic perspective, relatively little is known about the dietary influences on the development and maturation of fat cells. The effects of various types of dietary fats on the process of adipogenesis of precursor human and mouse cells is being investigated.

Economic studies suggest that organically grown fruits and vegetables could be a new growth industry within the southeast. Consumption habits and food choices as driven by health promotion, perceived or real, are leading to agricultural economic growth. Economic and sociological models are being examined for numerous commodities.

Internal and External Linkages

Multi-Institutional:

The Institute of Nutrition (ECU, NC A&T, NCSU, UNC-CH, and UNC-G)
Food Safety Science Continuum (proposed) (NCSU, UNC, and NC A&T)

Multi-Disciplinary, Multi-Subject:

Food Safety Science Continuum (proposed)

Pre- and Post-Harvest Food Safety
Food Safety Training - Foodservice Industry
Microbial Adaptation
Rapid and Improved Detection Methods and Biosensors
Molecular Epidemiology
Quantitative Microbial Risk Assessment and Analysis
Consumer Education

Target Audiences
Human nutrition and human health research is intended ultimately for all citizens. The stakeholders include the university research community, the North Carolina Cooperative Extension Service (state and county programs), state and private medical well-being programs, North Carolina Department of Agriculture, North Carolina Department of Community Health, North Carolina Department of Environmental Health-Public Health Pest Management, and The North Carolina Department of Health and Human Services.

Program Duration
Long-term, 5 years.

Allocated Resources
Following are expenditure and commitment data for 1997-1998. Similar expenditures and personnel commitment are expected over the next five years.

EXPENDITURES

Source	Amount
CSREES Funds	$93,397
USDA-CGCA Funds	$0
Other Federal Funds	$91,647
State Appropriation	$964,000
Non-Federal Funds	$182,514
Total	$1,331,514

PERSONNEL COMMITMENT

Scientist Years	7.64
Professional Years	5.16
Technician Years	4.01
Clerical Years	0.96
Total	17.77

Human nutrition and human health includes projects in food choices, habits and consumption, preventing transmission of animal diseases and parasites to man, a variety of human nutrition projects, and a focus on hazard reduction for health and safety. As a percent of total funds, food choices, habits and consumption research receives 7.68 percent; preventing animal disease transmission and parasites in man research account for 28.04 percent funding; while human nutrition research receives the largest share at 56.81 percent and reducing hazards to health and safety the smallest at 7.47 percent. The proposed Food Safety

Science Continuum will require core faculty time, internships, tuition remission, waiver of portion of indirect costs and dedicated facilities.

National Goal 4:
An Agricultural System Which Protects Natural Resources and the Environment

Program Area 9:
Soil, Water and Air Quality Conservation and Management

Statement of Issue

Food security problems (famine, malnutrition, etc.) occur in regions with high population growth rates and with farming methods that are inefficient and unproductive. In contrast, developed countries utilizing contemporary agricultural technologies are self-sufficient in food production and provide the majority of food exports. As the world population increases toward a projected 12 billion in 2050, our continued ability to produce sufficient food and fiber depends on progressive increases in crop productivity per unit land area. Under increasing production pressure, conservation of our limited natural resources and protection of the quality of our environment can only occur with continued advances in and adoption of agricultural technologies. Therefore, protecting the environment and the quantity and quality of our natural resources is essential for meeting future demands for food and fiber and insuring world food security.

North Carolina's natural resources and climate enable diverse and productive agriculture and forestry systems; however, current and projected urban and suburban growth places considerable pressure on natural resources and the environment. Therefore, sustaining and/or increasing agricultural and forestry production must occur on a declining land resource base. In addition, the public expects that agricultural and forestry enterprises maintain environmental quality and adopt new production technologies and/or environment protection practices to enhance degraded soil, water, or air resources. Therefore, it is essential that agricultural technologies be developed that can enhance agricultural productivity and profitability, while maintaining the quality of our soil, water, and air resources. North Carolina State University and the College of Agriculture and Life Sciences are responsible to the public for development of appropriate, cost-effective technologies and assist stakeholders to understand and adopt technologies appropriate for insuring environmental quality and natural resource protection.

Performance Goal

The primary goal of this research program is to enhance our understanding of the physical, biological and chemical processes and interactions influencing agricultural and forest ecosystem productivity. The interdisciplinary research projects will advance knowledge of natural processes to enable development of production management and environmental protection technologies that will:

1. enhance productivity;
2. improve input efficiency;
3. conserve natural resources; and
4. improve and protect environmental quality.

Key Program Components

The program area represents interactions between diverse ecosystems (agriculture, forestry, coastal

zone), issues (productivity, profitability, resource conservation, environmental quality) and clientele (producers, urban/suburban public, recreation, consumers, etc.). The primary research focus will be on soil and water quality and management, nutrient and waste management, and air quality. The following list identifies research programs currently being conducted and/or planned for the next five years.

- Soil and water quality and management:
  - Soil erosion and sedimentation processes and prevention
  - Soil productivity and management
  - Soil resource characterization and assessment
  - Surface and drainage water conservation and management
  - Irrigation water management and systems engineering
  - Watershed and estuary protection and management
  - Water quality assessment and monitoring
  - Wetland and riparian zone characterization, protection, and management
  - Water and solute transport and interactions with soil
  - Groundwater and surface water quality assessment and protection
  - Alternative land uses

- Nutrient and waste management:
  - Nutrient, soil, water, and plant interactions
  - Nutrient cycling and modeling
  - Animal, municipal, and industrial waste utilization and management
  - Added value waste product development
  - Septic waste management
  - Fertilizer use efficiency and management
  - Precision agriculture
  - Economic assessment of alternative nutrient and waste uses and management practices

- Air Quality:
  - Air quality assessment and monitoring
  - Soil, plant, atmosphere modeling for nitrogen, sulfur, carbon and other constituents

Soil, nutrient, and waste management to contaminants
Waste management systems to reduce odor
Ecosystem assessment and impacts

Projects involving soil and water quality and management will comprise approximately 50 percent of the personnel and operating resources. Approximately 40 percent of resources will be allocated to nutrient and waste management projects. Projects involving air quality will constitute a total of 10 percent of resources.

These broadly defined projects will result in development of natural resource and environmental management technologies that satisfy the performance goals and meet the technological needs of the target audiences. New technologies in soil, water, nutrient, and waste management will protect surface and ground water resources from contaminants related to input use in agriculture and forest production. Soil, water and air quality monitoring projects will assess impacts of current and emerging technologies on reducing contaminant loading in the environment. These monitoring projects exist in traditional cropping systems and well an in managed turf systems, forestry, and coastal zone ecosystems. These data will

quantitatively document the impacts of selected technologies and best management practices on soil, water, and air quality. Cooperation technology transfer projects with North Carolina State University Cooperative Extension faculty will document the extent of adoption of best management practices by producers, dealers, consultants and other agricultural and environmental professionals.

Internal and External Linkages

The faculty in the College of Agricultural and Life Sciences conduct interdisciplinary research in each program area (see "Allocated Resources"). Faculty conduct cooperative research with scientists in most departments in the College of Agricultural and Life Sciences:

Agricultural Resource Economics
Animal Science
Biochemistry
Biological and Agricultural Engineering
Botany
Crop Science
Entomology
Horticulture
Plant Pathology
Poultry Science
Soil Science
Statistics
Toxicology
Zoology

In addition, College of Agriculture and Life Sciences faculty cooperate with faculty in the:

College of Forest Resources
College of Physical and Mathematical Sciences
College of Engineering

The success of current and future projects depends on interdisciplinary cooperation with scientists at universities throughout North Carolina and many other states. They include:

North Carolina A & T State University
Duke University
University of North Carolina (Chapel Hill)
University of North Carolina (Wilmington)
University of North Carolina (Charlotte)
University of North Carolina (Asheville)
University of Georgia
Kansas State University
Virginia Polytechnic Institute and State University
University of California-Davis
Clemson University
University of South Carolina
University of Tennessee (Knoxville)
University of Florida (Gainesville)
Iowa State University
University of Missouri
Michigan State University
Ohio State University
Purdue University
University of Illinois
Mississippi State University
Pennsylvania State University

Many scientists and other professionals in industry and with state and federal agencies provide essential cooperation with North Carolina State University scientists. They include:

North Carolina Department of Environment and Natural Resources
Division of Water Quality
Division of Air Quality
Division of Soil and Water
North Carolina Agricultural Statistics
North Carolina Department of Agriculture and Consumer Services
USDA-ARS
USDA-EPA
USDA-APHIS
NASA

USGS	NRCS
DOE	DOD
Brookhaven Laboratories	United Soybean Board
U.S. Golf Association	The Fertilizer Institute
National Wheat Growers Association	Potash Corporation of Saskatchewan
Southern States Cooperative	Farmland Industries
DuPont	Monsanto
Novartis	AgChem Equipment Co.
John Deere Inc.	North Carolina Pork Council
Open Grounds farm	Perdue Farms
North Carolina Plant Food Association	Cotton Incorporated
North Carolina Cotton Growers	North Carolina Peanut Growers
North Carolina Corn Growers	North Carolina Soybean Growers
North Carolina Wheat Growers	North Carolina Sweet Potato Growers
North Carolina Tomato Growers	North Carolina Christmas Tree Growers
North Carolina Turfgrass Council	

Target Audiences
Natural resource and environmental protection benefits all citizens of North Carolina. The direct users of research and technology development are the producers, dealers, consultants, and other agricultural and environmental professionals. Personnel in state and federal regulatory agencies and legislators also are important target audiences. The public demands high-quality water and air resources, thus agricultural and forestry production practices must protect environmental quality. The public trusts our ability to protect the environment and to provide quality food and fiber. Therefore, we should continually communicate our progress toward these goals.

Program Duration
Long-term, 5 years

Allocated Resources
Interdisciplinary soil, water, and air quality conservation and management research programs involve faculty from four colleges (Agriculture and Life Sciences; Engineering; Forest Resources; and Physical and Mathematical Sciences). In the College of Agriculture and Life Sciences, nearly 60 faculty in 14 departments are involved in nearly 150 projects in 11 categories including:

- appraisal of soil resources;
- soil, plant, water, nutrient relationships;
- management of saline and sodic soils;
- alternative uses of land;
- conservation and efficient use of water;
- efficient drainage and irrigation systems;
- watershed protection and management;
- economic and legal problems in water and watershed management;
- adaptation to weather and weather modification;
- remote sensing; and
- alleviation of soil, water, and air pollution and disposal of wastes.

Following are expenditure and commitment data for 1997-98. Similar expenditures and personnel commitment are expected over the next five years.

EXPENDITURES

Source	Amount
CSREES Funds	$1,156,241
USDA-CGCA Funds	$131,693
Other Federal Funds	$1,093,094
State Appropriation	$5,908,681
Non-Federal Funds	$2,194,942
Total	$10,484,651

PERSONNEL COMMITMENT

Scientist Years	24.58
Professional Years	29.83
Technician Years	53.36
Clerical Years	15.62
Total	123.39

Program Area 10:
Forest, Pasture, Wildlife and Fish
Resource Conservation Management

Statement of Issue
Conservation and management of forests, wildlife and aquatic resources require an understanding of the structure and function of the ecosystems which they comprise. This knowledge is especially important in the intensively managed agricultural and suburban landscapes of North Carolina as human influences are pervasive. Of special note are the interfaces between terrestrial and marine environments and the steep and fragile forested ecosystems of the western mountains. Research on the biology and ecology of plant and animal communities provide the basis for developing conservation policies and management practices for these resources. For forest and plant communities fundamental information needs include assessment of soil and water properties, production potential of plants and environmental factors that control or limit production. For animal communities informational needs include population biology, interactions with oth er animals, and the role of habitat in controlling or limiting the success of populations and communities. Such information on the biology and ecology of forest, wildlife and aquatic species serves as the basis for formulating policies and practices for their management.

Performance Goals

1. To understand relationships between soil fertility and plant communities.

2. To identify biological and physio-chemical factors that influence establishment and growth of trees.

3. To describe physiological mechanisms controlling reproductive biology of fish.

4. To develop improved understanding of the habitat factors the influence the reproduction and survival of terrestrial wildlife.

5. To identify environmental factors that influence the reproduction, recruitment and survival of fish.

Key Program Components
This program area involves 27 projects in 8 departments. Projects encompass work on identifying biological and physio-chemical factors that influence the reproduction, development, growth and survival of plants and animals and elaborating the mechanisms by which these factors do so. The following summary of general themes characterizes the projects.

Assessing Forest Resources: 3 projects in 2 departments are characterizing soil fertility and disease organisms in forests and elucidating their relationships to plants.

Biology and Culture of Forests and Timber-Related Crops: 5 projects in 2 departments are developing further understanding of biological properties that are likely involved in controlling the success of propagation and culture of horticultural trees. These include studies of entomopathogens, soil arthropods, and improved propagation and cultural practices.

Wildlife Studies: 9 projects in 3 departments are studying environmental influences on the biology and dynamics of terrestrial populations. Especially noteworthy are 4 projects dealing with the conservation biology of threatened or endangered species, particularly the influence of habitat upon the reproduction, growth and survival of these species.

Fisheries studies: 11 projects in 2 departments are studying the effects of environmental influences on the reproduction, recruitment and survival of fish species that are commercially or recreationally important. Studies include evaluation of habitat in freshwater reservoirs, assessment of spawning habitat for anadromous fish, and studies of esturarine factors affecting recruitment of juvenile marine species into the fisheries.

Output indicators:
These performance goals generally involve fundamental research on typical ecosystems. As a consequence, the output indicators are principally the dissemination of this information and its use by other scientists. Indicators include the dissemination of knowledge to scientific colleagues, postgraduate and graduate students, undergraduate students and K-12 teachers through peer-reviewed publications, technical publications, seminars, presentations at scientific conferences, classroom instruction, student laboratory training, teacher workshops, and web access to publications. Other audiences are natural resource managers and policy makers.

Internal and External Linkages
This program area includes faculty from eight departments in the College of Agriculture and Life Sciences (Agricultural and Resource Economics, Botany, Entomology, Horticulture, Plant Pathology, Statistics,

Toxicology and Zoology). Many projects are interdisciplinary and involve faculty from different departments or institutions. Faculty work freely across departmental and college lines. The Department of Zoology is host to the USGS Cooperative Fisheries and Wildlife Cooperative Research Unit, which facilitates interdisciplinary research among several departments and colleges at NC State.

External linkages include faculty from a number of universities including the University of North Carolina at Chapel Hill and at Wilmington, Eastern Carolina University and Duke University. The National Marine Fisheries Service Laboratory in Beaufort, the N.C. Division of Marine Fisheries and the N.C. Wildlife Commission are partners in several projects. The presence of the USGS Unit in the Department of Zoology facilitates partnerships with several federal agencies, especially on issues of conservation biology and fisheries management.

Target Audiences
The national and international community of scientific researchers and teachers is the principal target audience. Other audiences include natural resource managers and policy makers.

Program Duration
Long-term, 5-plus years

Allocated Resources
Following are expenditures and commitment data for 1997-98. Similar expenditures and personnel commitment are expected over the next five years.

EXPENDITURES

Source	Amount
CSREES Funds	$206,344
USDA-CGCA Funds	$11,121
Other Federal Funds	$1,127,393
State Appropriations	$1,288,810
Non-Federal Funds	$413,159
Total	$3,046,827

PERSONNEL COMMITMENT

Scientist Years	7.61
Professional Years	13.45
Technician Years	10.48
Clerical Years	1.52
Total	33.06

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

Program Area 11:
Improved Quality of Life

Statement of Issue

The green industry locally, regionally and nationally has experienced phenomenal growth in recent years. Commercial flower production; ornamental nurseries; landscape design and maintenance; and turf production and maintenance constitute the major enterprises in the green industry. This is a segment of agriculture that has recorded double digit growth over the past 10 years. There are many issues that these industries face, from environmental to production problems. To provide the service and the aesthetics that the general public expect from this industry, research efforts must be undertaken to solve environmental and production problems as well provide the industry and ultimately the public with a more diverse selection of plants for the landscape. During periods of economic prosperity in the country, individuals and corporations invest more in enhancing their living environment and spend more on outdoor recreational activities such as golf and gardening. This translates into more demand for products and services from the green industry.

Because many golf courses are in critical drainage systems and near wetlands, fertilizer residues cannot be allowed to run off into the streams and rivers. If regulations go into effect preventing chemical use on turf, golf courses could be shut down and the quality of life for many people decreased. However, we do not know if there is a problem if good management practices are used. Studies need to be implemented to better understand nitrogen application and its fate in recycling on golf turf as opposed to runoff in surface or underground water so lawmakers can have data to make good policy decisions.

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, they serve as indirect pests through their nuisance value and by destroying the buildings we live in. Each of these aspects results in serious economic losses to our state and the nation as well as reducing the quality of life enjoyed by literally every citizen.

Performance Goals

1. Develop improved production management systems for ornamental and floricultural crops and turfgrass.

2. Develop and introduce superior landscape plants to enhance rural and urban environments.

3. 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.

Key Program Components
NCARS program area 11 involves 31 different projects in six departments. These projects have been grouped into three categories as outlined under performance goals.
Performance Goal 1.
A total of 25 projects are underway in this category with six in the turf area and 19 in ornamentals/turf. In the turf area research that will be conducted includes weed and disease management; breeding and genetics; and fertility and water management. Ornamentals and floriculture research to be pursued includes pest (weeds, insects and diseases) management; hydrology of horticultural substrates and urban soils; improved propagation procedures for selected ornamental species; production, culture, and physiology of landscape plants; fertility and nutrient management in floral and ornamental crops; breeding and genetics of ornamentals; taxonomy of ornamental plants; and development of environmentally compatible nursery production practices.

Performance Goal 2.
This goal involves the identification of superior landscape plants for the Southern U.S. Two related projects will be involved in this category. The first project to be pursued is evaluation of plants for landscape use in the southeastern U.S. which essentially covers one of the missions of the J.C. Raulston Arboretum (JCRA). This will involve plant exploration and exchange, on site evaluation at the JCRA and satellite sites; and introduction of superior performing plant material to the nursery industry through a plant introduction program. The other project will address the evaluation of various tree species for performance in all the geographic areas of NC for performance and such attributes as suitability under utility lines.

Performance Goal 3.
There will be four different projects associated with this goal. This is a goal that is classified under the heading of control of insect pests of man and his belongings. Research in this area will include biology, physiology, and management of wood destroying and urban insect pests; insect-specific target systems for the development of novel tools for cockroach control; biology and control of nuisance vector arthropods in North Carolina; and potential vectors of dirofilaria immitis in North Carolina.

Output Indicators:
These performance goals involve research with direct application to the commercial producer with ultimate benefits to the consuming general public. Anticipated outcome indicators include:

- adoption of more efficient production practices for ornamental and floricultural crops;

- application of sustainable production techniques for ornamental and turf production that result in reduced risk of off site movement of nutrients and pesticides;

- use of improved ornamental and turf varieties that have multiple disease resistance, insect resistance and improved quality characteristics;

- use of ornamental and turf varieties adapted to a wide range of environmental conditions and physiological stresses;

- use of nonchemical methods of pest control and/or reduced pesticide use through application of IPM strategies; and

- development of effective methods for controlling insects pests of people and their belongings.

Internal and External Linkages
Internal linkages exist with several CALS departments in this program area. Major players in this program include faculty from the Horticultural Science, Entomology and Plant Pathology departments who cooperate with faculty from Soil Science, Statistics, Poultry Science, Animal Science, Botany, and Genetics. Multi-state collaboration exists in many of the programs both formally through SRIEG agreements and Memorandums of Understanding and informally between individual faculty at a number of land grants in the southeast and other regions of the country. Cooperative efforts also exist with such commodity groups as the N.C. Association of Nurserymen and the N.C. Landscape Association in terms of plant introduction programs. Additionally, a number of the projects have direct and indirect international collaborations both with individual countries and international centers in Central and South America, Europe, Africa and Asia. Both the internal and external linkages greatly enhance research efforts within this program area.

Target Audiences
Producers of ornamental and floricultural crops and turfgrass managers and pest control operators in North Carolina are the primary stakeholders or clientele of this program area. However, the ultimate beneficiary of these efforts is the public at large as results of this research touch the lives of almost every citizen of the state with regard to quality of life. Although efforts are targeted for North Carolina, results of the research often have regional, national and international implications.

Program Duration
Long-Term, 5-plus years

Allocated Resources
Following are expenditure and commitment data for 1997-98. No major shifts appeared to be warranted. However, in view of the growth in the turfgrass industry some additional resources may be warranted.

EXPENDITURES

Source	Amount
CSREES Funds	$344,183
USDA-CGCA Funds	$0
Other Federal Funds	$124,804
State Appropriations	$2,147,253
Non-Federal Funds	$508,762
Total	$3,125,002

PERSONNEL COMMITMENT

Scientist Years	8.60
Professional Years	7.25
Technician Years	13.64
Clerical Years	7.79
Total	37.28

Program Area 12:

Individual, Family and Community
Economic Development

Statement of Issue

The well-being of rural people and areas in North Carolina remains uncertain. Restructuring of jobs and industries, changes in the age, gender, and racial/ethnic composition of local populations, the devolution of government programs, and changes in how land and other natural resources are used and by whom all affect rural people and communities in North Carolina. Despite growth in the high-tech urban areas, rural North Carolina lags behind. Poverty persists, and its effects are exacerbated by shrinking budgets for public goods and services at the same time that demand grows. Rising awareness of the environmental consequences of new technologies increases demands on rural localities for social, economic and environmental impact assessment. The distinct needs of growing and culturally diverse populations in North Carolina, including the elderly, will create challenges as well as opportunities. At the same time, there is a growing commitment to enhance the quality of life and economic viability of rural families and communities. These trends and changes have a profound impact on rural community structure and organization, on community sustainability, and on quality of life.

Continuing long-term trends, our rural areas lag urban areas in levels of earnings and income, have lower high school graduation rates, exhibit more poverty, have higher rates of infant mortality, unemployment and stress and, in some cases, the gap may be widening. Most population growth within the state is in urban areas. Within rural areas, disproportionate shares of minorities remain economically disadvantaged, although some signs of improving socioeconomic conditions are beginning to appear. According to most indicators, economic disadvantage is especially pronounced in rural areas with large concentrations of minority population.

Increasingly, local affairs are influenced by state, national, and global circumstances and policies. Cyclical changes in the economy at the state, national and global levels creates uncertainty as to whether local efforts can respond to change. At the same time, long-term economic trends which encourage consolidation and integration of industries have effected rural North Carolina. Maintaining an effective international competitive position for food and fiber produced in the state, especially as new policies and decisions on international trade emerge, is becoming more difficult. Technological advances in communication and transportation have made rural communities more susceptible to national and global changes. And this is further exacerbated by an increasingly complex web of state, national, and international laws and regulations that affect local businesses and communities.

Recent declines in rates of employment and population growth point to a possible slowdown in the favorable economic conditions prevailing in rural areas of North Carolina during much of the current decade. Employment growth in rural areas has dropped below the rate for urban areas in recent years. Further, this decrease in rural employment growth extends across the state, signaling the continuing shift in economic activity toward our urban areas. However, falling unemployment levels, growing per capita incomes, and rising weekly earnings for rural workers in North Carolina indicate the continuation of a positive economic climate. Nevertheless, challenges remain considerable in many rural counties, cities, and towns of the state. Economic shifts are forcing many manufacturing firms to close or depart for overseas locations. Those persons without a post-high school education, or lacking relevant job training, are finding it more difficult to find jobs paying decent wages. And, larger numbers of employers are seeking workers

with problem-solving and technology-related skills. Much greater attention will need to be given the workforces of rural areas and to devise strategies that will position them to be full partners in a global, complex economy. Rural workers need improved understanding of their employment options and their training and education opportunities.

Performance Goals

1. Improve domestic and international market potential.

2. Develop new strategies for rural development.

3. Advance understanding of factors that improve individual, family, and community economic and social viability.

4. Become a resource for social, economic, and environmental impact analysis.

Key program components
Research projects will focus on:

- strategies individuals, families, farms and communities use to respond to global rural restructuring;

- improved methods to measure real consumer prices, wages and business cycles;

- factors contributing to racial earnings inequalities;

- agricultural policy related to quotas, price supports and marketing boards;

- demographic and socioeconomic factors related to rural economic development;

- factors that influence youth development and career aspirations, agricultural injury and substance abuse; and

- changes in the organization of local labor markets.

Output indicators:

- Greater understanding of the impact of family interaction patterns, information acquisition, and resource management practices on individual and family economic social viability.

- Strategies for economic diversification, entrepreneurship, and job creation.

- Enhanced understanding of the factors that influence the state's competitiveness within traditional and emerging markets.

- Increased awareness of employment requirements and opportunities and education and training possibilities.

- Methodologies for social, economic and environmental impacts.

Outcome indicators:

- Increased trade and sustained farm income (or favorable changes in farm income and well-being).

- Economically improved communities.

- Increases in economic, human, environmental social capital.

- Increased youth and service agencies participation in career development programs.

Internal and External Linkages
Multi-State:
Regional Rural Restructuring Project S-276 (NC, AL, GA, IA, KY, LA, MI, OH, SC, TX, WI, Puerto Rico)

Regional Commodities, Consumers and Communities Project NE-185 (NC, KS, MI, MD, WV, WI, CA, NJ, MO, IA, WA, NY, PA and NGOs)

Regional Rural Labor Markets Project S-259 (NC, OH, LA, MD, AL, IA, Puerto Rico SC, MI, KS, WV, AR, TN, MS, GA, USDA-ERS, non-profits and other NGOs)

Regional Rural Economic Development Project NE-162 (NC, AZ, CA, DE, GA, IN, KY, MI, MO, NV, NH, NY, OH, OR, PA, SC, UT, TX, VA, WA, WI, WY)

Multi-Institutional:

NC A&T State University
Brigham Young University
Southern Rural Development Center
Winthrop University
CAFF
AppleSchram Orchard
Food for Lane County
Rural Development Center
Levy Economics Institute
Minnesota Institute for Sustainable Agriculture
Minnesota Food Association
Hartford Food System
University of North Carolina-Chapel Hill
East Carolina University
Saint Louis University
National Catholic Rural Life Conference
Illinois Stewardship Alliance
Sustainable Food Center
Appalachian Sustainable Development
SeaChange
Just Food
SLUG
NESAWG
NC State Occupational Information Coordinating Committee
N.C. Department of Public Instruction
Duplin and Burke County Schools
Boys' and Girls' Clubs

Multi-disciplinary:

Demography, sociology, agricultural economics

Target Audiences
Local and state policy-makers, citizens of the state, state agencies, Cooperative Extension Service (especially rural economic development specialists, and family and consumer science specialists), 4-H and voluntary youth workers, church youth directors, sociologists, economists, demographers and other university scholars.

Program Duration
Long-term, 5 years

Allocated Resources
Following are expenditure and commitment data for 1997-98. Similar expenditures and personnel commitment are expected over the next five years.

EXPENDITURES

Source	Amount
CSREES Funds	$125,267
USDA-CGCA Funds	$23,052
Other Federal Funds	$42,788
State Appropriation	$573,941
Non-Federal Funds	$136,460
Total	$901,508

PERSONNEL COMMITMENT

Scientist Years	2.89
Professional Years	4.29
Technician Years	0.86
Clerical Years	4.14
Total	12.18

II. RESEARCH 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 of the 350 research faculty also have extension appointments. These faculty are the primary day-to-day communication link between agribusiness, county extension offices and NCARS. Because their research and extension activities are directed toward the development-implementation phase of new knowledge and technology, they are constantly relating industry needs and suggestions to other researchers whose emphasis is more in the discovery phase. In addition, these faculty interact with county extension personnel in such a way that input from individual consumers is also effectively communicated to NCARS administration and faculty.

Stakeholder input utilized in determining research program directions is also received through numerous formal advisory groups. NCARS interacts with 90 official commodity and agricultural industry associations from within North Carolina. An NCARS representative attends at least one and sometimes more meetings or conferences of these associations 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 meetings so that any individual there can contact them and discuss whatever issues they desire.

Of the 90 state agricultural industry associations, 24 provide funding to various research projects annually, usually on a competitive basis. In these cases, an NCARS representative sits with the association's board of directors at least twice per year; first, to determine high priority research areas to be used in the request for proposals and second, to assist the board in deciding which proposals to fund. This is the most targeted type of stakeholder input, having a direct effect on research activities within NCARS.

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 238 stakeholders from a wide range of agricultural interests. In addition, there are currently five formal centers within the college with industry advisory boards that meet at least twice per year, adding another 55 stakeholders providing NCARS administrators and scientists input and direction for research programs.

The college has two major foundations that support NCARS research each year, the Agriculture 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 of these foundations, approximately 70 members from Agriculture Foundation and 20 from Dairy Foundation, each fall to hear discussion on 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.

In the future to expand stakeholder input, NCARS is considering a number of options. These are: establish a research advisory committee of external stakeholders, possibly composed of subgroups formed around program areas; placing program area activity descriptions on the Internet and soliciting comments from key stakeholders and the general public; and becoming involved with the NC Cooperative Extension Service's advisory groups, primarily to listen to input during their meetings. The relative benefits of these and other options will be considered over the next year and decisions on implementation made during 2000.

III. RESEARCH PEER AND MERIT REVIEW PROCESS

NCARS Research Project Review

A thorough scientific and merit review of each proposed new or revised research project should be made at the departmental level prior to submission to the NCARS office. This departmental review should consist of two parts: an informal review (PI's responsibility) and a formal review (Department Head's responsibility).

Informal Review

The informal review should be performed on the initiative of the PI through interactions with other faculty, both within and outside of the department, and with various stakeholders outside the university. The stakeholder input may come from routine interactions with individuals or with groups at meetings, conferences, field days, etc. Keep in mind that primary stakeholders vary greatly between different research projects within NCARS. PI's developing projects with a specific commodity or industry orientation (i.e., swine nutrition, corn breeding, vegetable production, dairy foods) should interact with appropriate representatives of these groups. PI's developing projects of a basic, discovery nature (i.e., geminivirus replication, yeast proteasomes, RNA-protein interactions) may consider other university scientists or industry researchers working in a similar area their primary stakeholders and therefore, should consult with them for this informal review.

Consultation with faculty and stakeholders during the informal review phase should include inquires regarding both the scientific soundness of the proposed research and the relevance to the appropriate stakeholder groups' needs. In this formative stage, comments and suggestions from other faculty and stakeholders may be more productive and useful than those received later through the formal review process. All input should be considered and appropriate adjustments made as the research project outline is developed.

Formal Review

The Department Head must provide for a formal review of all proposed new and revised research project outlines prior to submission to NCARS. This review must be done by at least three faculty members with general knowledge of the proposed research subject area. At least one of these reviewers must be from outside the PI's home department. If the proposed research involves complex, unusual, and/or extensive statistical procedures, the outline should also be reviewed by the departmental statistical liaison. Each reviewer should be asked to comment on the research being proposed from two perspectives: (1) the scientific soundness of the hypothesis, objectives and procedures described in the outline; and (2) the relevance, or merit, of the research based on the previous work and present status of current work described in the outline and the reviewer's own knowledge of the needs in this research area.

The Department Head's office will send the draft outline to the selected reviewers asking for their comments within a specified time frame. The Department Head should request that the comments be submitted both to his/her office (to be retained in the project's file) and to the PI. The PI should then make appropriate revisions and submit the revised outline to their Department Head with an explanation regarding any reviewer comments that are not addressed in the revision. The Department Head should

confirm that comments were appropriately addressed and make a final determination on the relevance of the proposed research. After Department Head approval and completion of the necessary CRIS Web Forms, the final project outline should be forwarded in electronic form to NCARS for processing.

Multistate Research Project Review

Multistate research projects originating in the Southern Region that NCARS faculty are participating in receive merit and peer reviews according to guidelines established by the Southern Association of Agricultural Experiment Station Directors (SAAESD). These guidelines can be found at the following URL: http://www.msstate.edu/org/saaesd/infobook/guide/guide.htm Similar review processes exist for multistate projects originating in other regions.

Proposed multistate research projects that will not be processed through the SAAESD will receive merit and peer review by the following tentative process. Final guidelines will be developed as experience is gained by the partner institutions in working with multistate projects under AREERA. Project PI's will submit a written project proposal conforming to an outline format typical for the institutions involved. At the very least, the proposal will contain a title, justification, review of key literature, objectives, procedures, duration, personnel (with time commitments and funding arrangements (at least for the first year). The institution with the highest resource commitment to the project will take the lead in coordinating the review. The process will be an amalgamation of local peer review procedures. Upon mutual agreement, the administrators of the project PI's will decide on the number of reviewers and the home institution of these reviewers. If a multistate project includes an extension component, then appropriate extension reviewers will be included in the review panel. Multistate projects may run for up to five years and must include an annual review of progress towards achieving objectives.

IV. MULTISTATE, MULTIDISCIPLINARY RESEARCH ACTIVITIES

North Carolina Agricultural Research Service research faculty are active participants in 22 Southern Region Multi-state Research Projects and 14 additional Multi-state Research Projects administered in the North Central, North East and Western Regions. The project numbers, titles, total expenditures and total personnel efforts are shown in the following table. The expenditure of $3.22 million is well over 25 percent of North Carolina State University's Hatch regular and Hatch Multistate Research Fund allocations. Details of these multistate projects are on file with the Cooperative State Research, Extension and Education Service's Partners office.

In addition to these Multi-state Research Projects, NCARS has formal agreements in four other multistate research collaborations. These are listed below with a brief description of each.

▸ Peanut Variety and Quality Evaluation Project. 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 primarily bred by NCARS breeders, then evaluated in field trials managed by VAES researchers. Selections are evaluated, selected and approved for release by an advisory board composed of NCARS and VAES faculty and peanut growers and processors. NCARS annually provides one-half of the funds required to manage the field trials.

▸ Multistate Waste Management Consortium. A cooperative agreement is in place between NC State University, Iowa State University, Michigan State University, Purdue University, University of Missouri and Oklahoma State University to encourage collaborative projects in animal waste management. The members of this consortium each agree to allocate at least $75,000 annually to competitively awarded research projects on animal waste management that are jointly submitted by researchers from two or more of the member institutions. A panel of scientists from the six institutions plus USDA, EPA and animal agriculture industry representatives review and select proposals for funding.

▸ Southeastern Small Fruit Center. A cooperative agreement is in place between NC State University, University of Georgia and Clemson University to develop a web-based means of sharing and delivering research and extension information to the tri-state area related to the strawberry, blueberry, grape and bramble industries. NC State is providing the center director and assistant director (.20 SY and .20 TY); Clemson, the webmaster (1.0 TY); and Georgia, the web server and additional support funds. The center will also act as a coordinating body and clearinghouse for research and extension activities and industry needs related to small fruit production and marketing.

▸ Tomato Variety Improvement. A cooperative agreement is in place between NC State University and Clemson University for the improvement of fresh and processing tomato varieties for North Carolina and South Carolina production and marketing. An NC State breeder, stationed at the Mountain Horticultural Crops Research and Extension Center in Fletcher, N.C., is partially supported by funds allocated annually from Clemson University. In exchange, his tomato breeding program includes developing varieties with characteristics specifically favorable to South Carolina

growers and field tested in South Carolina.

NCARS Multi-State, Multi-Disciplinary Projects (1998)
Total Expenditures and Commitments

Project Number	Project Title	Total Funds	Total Effort
NC 136	Improvement of Thermal Processes for Foods	$105,130	1.60
NC 140	Rootstock and Interstem Effects on Pome- and Stone-Fruit Trees	$934	0.00
NC 168	Advanced Technologies for the Genetic Improvement of Poultry	$151,845	1.40
NC 205	Ecology and Management of European Corn Borer and Other Stalk-boring Lepidoptera	$11,516	0.20
NE 060	Genetic Bases for Resistance and Immunity to Avian Diseases	$27,524	0.20
NE 103	Postharvest Physiology of Fruits	$49,524	0.50
NE 123	Functional Properties of Food Proteins	$335,728	5.10
NE 148	Regulation of Nutrient Use in Food Producing Animals	$24,961	0.10
NE 162	Rural Economic Development: Alternatives in the New Competitive Environment	$8,488	0.00
NE 179	Technology and Principles for Assessing and Retaining Postharvest Quality of Fruits and Vegetables	$143,080	2.90
NE 184	Development of New Potato Clones for Environmental and Economic Sustainability in the Northeast	$27,962	0.30
NE 185	Commodities, Consumers and Communities: Local Food Systems in a Globalizing Environment	$32,958	0.18
S 009	Plant Genetic Resources Conservation and Utilization	$19,314	0.20
S 183	Phenology, Population Dynamics and Interference: a Basis for Understanding Weed Biology and Ecology	$60,197	0.50
S 222	Fruit and Vegetable Supply Chain Management, Innovations and Competitiveness	$180,225	4.10
S 233	Genetic Relationships of Growth and Reproduction in Diverse Poultry Populations	$68,210	3.00
S 257	Classifying Soils for Solute Transport as Affected by Soil Properties and Landscape Position	$184,851	2.09
S 259	Rural Labor Markets in the Global Economy	$96,382	2.90

Project Number	Project Title	Total Funds	Total Effort
S 261	Interior Environment, Energy Use in Poultry and Livestock Facilities	$290,770	3.40
S 262	Diversity, Interactions of Beneficial Bacteria and Fungi in the Rhizosphere	$79,712	1.60
S 263	Enhancing Food Safety Through Control of Foodborne Disease Agents	$11,200	0.10
S 265	Development and Integration of Entomopathogens into Pest Management Systems	$142,319	3.70
S 266	Parameter Sensing and Control Systems for Drying Agricultural Commodities	$155,924	1.80
S 267	Biological Control of Selected Arthropod Pests and Weeds	$277,980	4.00
S 270	Utilizing Potassium Buffering Capacity to Predict Cotton Yield Response to Potassium Fertilizer	$1,175	0.00
S 272	Development of Textile Materials for Environmental Compatibility and Human Health and Safety	$13,278	0.11
S 273	Development and Application of Comprehensive Agricultural Ecosystems Models	$86,686	0.48
S 275	Animal Manure and Waste Utilization, Treatment and Nuisance Avoidance for a Sustainable Agriculture	$4,907	0.00
S 276	Rural Restructuring: Causes and Consequences of Globalized Agricultural and Natural Resource Systems	$148,638	2.40
S 278	Food Demand, Nutrition and Consumer Behavior	$228,283	1.40
S 280	Mineralogical Controls on Colloid Dispersion and Solid-phasespeciation of Soil Contaminants	$53,502	0.30
S 282	Managing Plant-parasitic Nematodes in Sustainable Agriculture with Emphasis on Crop Resistance	$13,887	0.00
S 283	Develop and Assess Precision Farming Technology and its Economic and Environmental Impacts	$86,010	0.00
S 284	Genetic Enhancement of Health and Survival for Dairy Cattle	$11,726	0.00
W 168	Seed Biology and Technology Investigations	$77,051	0.20
W 186	Genetic Variability in the Cyst and Root-Knot Nematodes	$11,312	0.10

Project Number	Project Title	Total Funds	Total Effort
Total		**$3,223,189**	**44.86**

V. INTEGRATED RESEARCH AND EXTENSION ACTIVITIES

Research and extension activities are integrated within the College of Agriculture and Life Sciences at the administrative, programmatic, departmental and faculty levels. The directors of the N.C. Agricultural Research Service (NCARS) and the N.C. 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.

Programmatically, research and extension activities are integrated formally in a number of key areas through the efforts of faculty serving in the role of research and extension coordinator or as a center director. Examples of programmatic areas where this has been particularly successful are water quality, animal waste management, integrated pest management, sustainable agriculture, air quality, small fruits and specialty crops. 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 whom have research or extension appointments.

The most complete integration of research and extension occurs at the individual faculty level. Almost 100 of the 350 college faculty with research appointments also have extension appointments. In fact, most of these split-appointment faculty have 50 to 80 percent 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 agribusiness through development, field testing and demonstration.

Since all faculty with research/extension split appointments 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. The following table shows the total expenditures and personnel commitments during 1998 for these projects under the NCARS research program areas and subprogram areas. The total expenditure of $7.68 million exceeds NCARS's total Hatch allocation.

NCARS Research/Extension Split Appointments (1998)
Total Expenditures and commitments

National Goal NCARS Program Area and Subprogram Area	Total Funds	Total Effort
1. An Agricultural System that is Highly Competitive in the Global Economy		
1. Technologically Integrated and Sustainable Crop and Livestock Production Systems		
Crop Production Systems	$593,896	7.22
Animal Production Systems	$1,059,067	11.06
Biological Systems	$7,588	0.10
2. Plant and Animal Germplasm, Genetic Resources and Conservation, and Plant Improvement		
Crop Improvement	$288,577	3.18
Animal Improvement	$588,006	8.05
3. Plant Protection Strategies		
Forest and Horticultural Crop Protection	$944,461	13.95
Agronomic Crop Protection	$992,671	9.14
4. Animal Diseases and Animal Health	$224,746	3.38
5. Farm Business Management, Economics and Marketing	$264,611	4.61
6. Product Development	$321,184	4.90
2. A Safe and Secure Food and Fiber System		
7. Food and Fiber Processing, Safety and Quality	$195,489	2.00
3. A Healthy and Well-Nourished Population		
8. Human Nutrition and Human Health	$72,908	1.30
4. An Agricultural System Which Protects Natural Resources and the Environment		
9. Soil, Water and Air Quality Conservation and Management	$947,360	11.47
10. Forest, Pasture, Wildlife and Fish Resource Conservation and Management	$193,614	1.99
5. Enhanced Economic Opportunity and Quality of Life for Americans		
11. Improved Quality of Life	$763,386	4.09
12. Individual, Family and Community Economic Development	$218,280	3.28
Grand Total	**$7,675,824**	**89.72**