Unit Review

Research

CRSS research faculty strive to discover new knowledge and evaluate innovative concepts and technologies to enhance science, improve the educational experience for students, continually update extension information to help ensure a sustainable and functional environment and profitable agricultural industry. Research efforts represent approximately 60% of the departmental EFT with the majority of faculty having research appointments ranging from 25% to 100%. However, some extension faculty have no research appointment but have active applied research programs. CRSS research programs range from fundamental to applied and are located at all three campuses. All research faculty are expected to supplement state support with extramural funding, translate their results into peer reviewed articles and work to help ensure that research findings are communicated to colleagues and stakeholders. Ultimately, research results are transformed into useful solutions to agricultural and environmental problems. In addition, research programs provide for the training of graduate students and post doctoral fellows; undergraduate students to obtain exposure to scientific research; and the exchange of concepts and techniques from visiting scientists. CRSS research programs focus in breeding/genetics/genomics, crop management and physiology, environmental sciences and weed science. Faculty work on a diverse array of row crops, vegetables and forages; water quality; soil, water and waste management; crop physiology; weed ecology and management; pesticide fate and carbon flux in crop canopies.

Main foci and purposes of research:

Breeding/Genetics/Genomics - There are active cultivar development and germplasm enhancement programs in cotton, forage grasses, forage legumes, novel oil crops, peanut, pearl millet, small grains, soybean, sunflower, and turfgrasses. These programs are complemented by genomics research to improve the efficiency of cultivar development and by functional genomics research to find genes conferring important agronomic traits in crop plants. Research programs are focused in the following areas:

- Cereal breeding/genetics/genomics – Development of wheat, rye, oats, triticale, and barley cultivars and germplasm adapted to the Southeast's climatic conditions, with superior grain and forage yield, agronomic traits, durable pest resistance, and end-use quality.
- Comparative grass genomics - Development of cross-taxon genomic tools for a wide range of cereals, genetic tools for finger millet, comparative functional analyses of agronomically important genes, and understanding the organization and evolution of *Triticeae* genomes..
- Crop genomics – Reveal basic principles of genetics and evolution in the genomes of model organisms, and accelerate assembly of the genomic frameworks that will permit such principles to be applied to the study and improvement of major crops.
- Cotton breeding/genetics/genomics- Development of genetically improved cotton germplasm using classical breeding techniques with a focus on new biotechnology tools such as DNA markers and gene transformation technology.
- Forage breeding/genetics/genomics – Breeding superior alfalfa and forage grass species for Georgia and the Southeast. Apply genomic approaches to improve the efficiency and effectiveness of cultivar development.
- Legume transgenics - Development of technology to facilitate genetic engineering of crop plants, deployment of transgenes of agronomic importance, and development of improved agronomic crops.
- Peanut breeding/genetics/genomics- Breeding superior peanut cultivars for Georgia and the Southeast and genetics of important agronomic traits in peanut. Development of molecular tools and information to reveal intrinsic genetic potential and support more efficient cultivar development.

- Soybean breeding/genetics/genomics - Development of superior yielding, multiple pest resistant soybean cultivars, development of molecular technologies to improve the efficiency of soybean cultivar development, identification and characterization of useful genetic variation for soybean improvemen.
- Sunflower and specialty oil breeding/genetics/genomics– Applied breeding and cultivar development in novel oilseeds and sunflower and molecular breeding and translational and comparative genomics in sunflower, peanut, and other oilseeds.
- Turfgrass breeding/genetics/genomics - Breeding superior warm-season turfgrass cultivars of bermudagrass and centipedegrass with lower water, pesticide, and management requirements and vegetative and seeded seashore paspalum cultivars with tolerance to salinity and other stresses. Development of cool season grasses, including tall fescue and bentgrass with disease and stress tolerance. Development of molecular tools to reveal intrinsic genetic potential and support more efficient cultivar development.

Crop Management and Physiology faculty - Faculty conducting research in crop management studies include but are not limited to cultivar selection and performance, tillage, fertility, irrigation, pest control and crop rotations. Research is conducted on all aspects of managing Georgia agronomic crops and turfgrass with the ultimate objective of developing systems that create sustainable profits while preserving the agricultural and natural resource base. Research on crop physiology is conducted to expand our scientific understanding of plant function and provide information needed to develop unique solutions to agricultural problems. Faculty programs focus on commodities:

- Cotton - Development of cotton management system to improve fiber quality and increasing cotton production efficiency.
- Forages - Understanding the cascading events which occur as livestock graze toxic endophyte-infected tall fescue pastures, identifying limitations to endophyte technologies and develop strategies to overcome those limitations, and development of diagnostic techniques to assist plant breeders (forages, small grains, peanuts) in quantifying disease and mutualistic organisms and/or mycotoxins in plant populations
- Grain crops - Improvement of yield, efficiency, and profitability of summer and winter grain production and to ensure a safe, abundant quality supply of grains for food and feed purposes.
- Peanut - Development of the agronomic practices that provide producers yield and quality and result in maximum economic return, while maintaining a sustainable cropping system. Addresing applied production issues that have a synergistic effect with pest management, mechanization, irrigation, and economic stability.
- Soybean - Evaluation of agronomic practices such as variety evaluations, Asiatic soybean rust detection and control, and plant growth regulation.
- Tobacco - Coordination of educational efforts of a team of specialists which work together to provide agents and growers alike the most up-to-date and factual information on flue-cured tobacco production, harvesting, curing and marketing available.
- Turfgrass - Evaluation of methods of water conservation, which includes use of alternative (non-drinking water) irrigation water (often more saline), with the latter in support of the halophytic seashore paspalum cultivars released by UGA for turf, forage, and land reclamation uses. Areas of research include salinity tolerance, drought resistance, and site assessment in relation to water use, sport field characteristics, salinity. Additional research evaluates factors that influence turfgrass root growth and the management of localized dry spots caused by water repellent soils and the evaluation of various turfgrass species to the environmental stresses of the southeastern USA.

Environmental Sciences - Research programs in the area of environmental sciences and natural resource management address a diverse spectrum of soil, water, and air related topics and issues facing Georgia

and the nation. The greatest emphasis of faculty in this area is on water quantity and quality which includes programs addressing agricultural and urban irrigation water management, sources of and management practices to reduce loads of phosphorus, sediment, and bacteria in surface water including animal, household, and industrial wastes, and abiotic and phytoremediation of contaminants in soil and water. Other programs in this area include research into fundamental chemical, physical, and biological processes that affect cycling, transport, and bioavailability of nutrients and contaminants, management and environmental affects on nutrient cycling, influences of biological activity on soil structure and function, use of morphological properties to understand and predict soil hydrology, and the surface-atmosphere exchange of gases. Research programs are focused in the following areas:

- Biomicrometeorology - This program examines the surface-atmosphere exchange of gases, turbulence and is generally focused on the exchange between the vegetated-canopy layer and its environment.
- Molecular Environmental Science - This research area is focused on providing a fundamental understanding of the processes controlling the cycling, transport, and bioavailability of nutrients and contaminants in the environment. Combining these capabilities with molecular biological ("omics") tools is providing new insights into the coupled physical, chemical, and biological processes and mechanisms controlling nutrient and contaminant behavior in the environment.
- Nutrient Management - Nutrient management research focuses on the biological and chemical pathways of nutrient cycling in soils, including how environmental factors affect the rates of nutrient cycling. Research methodologies include remote sensing methods and other protocols for mapping the spatial variability of soil properties, ammonia volatilization from surface applied urea fertilizer and animal manures and the development of better methods for the routine determination of soil pH and lime requirement.
- Remediation - This area includes abiotic remediation and phytoremediation. Iron in conjunction with metal sulfides has been used for the effective remediation of halogenated solvents in groundwater. Areas of research in phytoremediation include: the use of macrophytes *Schoenoplectus californicus* and *Typha angustifolia* in a pilot constructed wetland for sorption and bio-concentration of mercury, selinium, and arsenic in wastewater, trials using cattail and other wetland species to study remediation of aniline and nitrobenzene derivatives in highly contaminated ground waters of an abandoned chemical plant, sorption of TNT and other explosives on humic-clay mineral complexes, and the use of mushroom compost extract to increase the bioavailability and subsequent biodegradation of high concentrations of PAHs.
- Soil Biology and Biochemistry - This area investigates the influences of biological activity on soil structure and function. One focus of research is to understand how soil invertebrates (especially earthworms) affect water-stable aggregate formation and the associated turnover and accumulation of soil organic matter and nutrients. Another research area aims at understanding how microorganisms influence the soil environment, specifically the regions directly surrounding a microbial population. Research tools include standard soil microbiology techniques to study microbial life and soil organic matter, as well as the more advanced techniques of compound specific isotope analysis, nuclear magnetic resonance spectroscopy, and DNA-based methods. In addition to basic understanding of soil processes, these focus areas have implications for environmental quality, conservation management and carbon-sequestration in agricultural and forest soils.
- Soil Pedology: Faculty in Pedology conduct research on the genesis, landscape distribution, and interpretation of soils. An understanding of the processes important to formation and distribution of soils and features across the landscape is the basis for better interpretation of soil suitability for agricultural, silvacultural, and urban uses. Current research is focused on developing a more comprehensive understanding of hydraulic properties of soils and better methods to estimate these properties from soil and landscape properties including investigations of the relationships

between redoximorphic features and depth and duration of seasonal saturation; and soil-landscape relationships and their effect on landscape redistribution of water.

- Waste Management - The faculty in the waste management area conduct research on land application of industrial and animal wastes ("by-products"). Industrial by-products studied include coal combustion wastes (fly ash, gypsum), pulp and paper mill wastes, and sewage sludge. Fly ash and ash-organic mixtures have been evaluated as soil amendments and potting mixes and gypsum ($CaSO_4$) was shown to ameliorate aluminum toxicity effects on turf grasses. Animal wastes include different poultry manures, which are by-products of the large poultry industry in Georgia. Research objectives aim at understanding the chemistry of nutrients, trace metals and organic contaminants in these by-products, and preventing soil/water/crop contamination from land application. The waste management area includes a focus on on-site wastewater (septic) management systems. The purpose is to improve the effectiveness of these systems in treating wastewater. Work in this area has focused on the effect of biomats on water movement from drainfield trenches, the development of state regulations governing on-site systems, and the use of computer models to compare alternative systems.
- Water Resources - The effect of non-point sources of pollution on surface water quality is a primary focus. The primary pollutants of concern are phosphorus, sediment, and bacteria. The purpose of the research is to determine the sources of pollution and what effect best management practices (BMPs) have in reducing pollutant loads. Research has also focused on water conservation options through management changes, including turfgrass water management, conservation tillage in row crop areas, and irrigation scheduling for all areas through improved sensing and prediction of soil water deficits and rainfall. Water resource limitations of the state's aquifers and rivers has been the focus of another effort to aid the state in predicting the impact of water withdrawals on stream flows and groundwater levels.

Weed Science - The mission of the Crop and Soil Science Weed Science program is to develop environmentally acceptable, profitable weed management systems for agronomic crops, horticultural crop, turfgrass and non-cropland areas in Georgia. Recently, weed science faculty have developed programs in the ecology and management of invasive plants. Research programs focus in the following areas:

- Herbicide efficacy in agronomic and horticultural crops, and non-cropland areas
- Herbicide physiology including herbicide resistance
- Environmental fate of herbicide in soil and water systems
- Minor crop herbicide registrations (IR-4 program) and third party herbicide registrations
- Herbicide-resistance weed management and weed management challenges resulting from the use of herbicide-resistant crops
- Computer-based software for weed management decisions
- Cultural practice interactions with crop weed management
- Weed sensor sprayer technology related to precision agriculture
- Alternatives for methyl bromide in plasticulture vegetable production
- Invasive plant ecology and management

Primary strengths in research:

CRSS maintains a multi-locational, multi-functional and interdisciplinary department that continues to meet a demand for increasingly complex research by maintaining primary research strengths in four disciplines. The diversity of CRSS research programs provides an opportunity to pursue new areas of science. Having faculty at all three locations provides CRSS faculty helps to effectively meet our state-wide mission. Teaching programs at Tifton and Griffin provide faculty with to participate in the educational process. In addition, extension faculty have increasingly become involved in applied research. These diverse demands have resulted in some faculty being responsible for all three functions. CRSS

faculty will continue to focus their research efforts in order to excel while fulfilling a complex state-wide programmatic mission. CRSS faculty have established and maintained a reputation for research strengths as follows:

Breeding/Genetics/Genomics

- Breeding of warm-season and cool-season turfgrasses and forage grasses, peanut, wheat, and soybean
- Molecular breeding of cotton, soybean, and sunflower
- Transgenic improvement of legume crops
- Comparative genomics of a wide range of dicot and cereal crops
- Structural and functional genomics of cotton, peanut, and sunflower

Crop Management and Physiology

- Multidisciplinary or team approach to research across all areas of research examples include NESPAL and Center for Soybean Improvement
- Micro Gin facility
- Accessibility to the UGA Monoclonal Antibody Facility
- Rhizotron facility

Environmental Sciences

- Use of the Soil Water Assessment Tool (SWAT) for modeling P and sediment loading to reservoirs in Georgia that are threatened by eutrophication.
- Use of automated sampling for collecting storm samples from edge-of-field experiments and from streams.
- Availability of high-quality analytical services (Laboratory for Environmental Analysis) within the Department to provide fee-based trace contaminant analysis (organic and inorganic) for research dealing with remediation and contaminant fate and transport.
- Use of miniature radio communications technology with soil moisture and weather variable sensing for use in irrigation management.
- Expertise in soil invertebrate taxonomy and systematics.
- Use of stable isotopes (^{13}C, ^{15}N) and mass spectroscopy in studies of soil organic matter dynamics and soil biological processes.

Weed Science

- The primary strengths of the Department of Crop & Soil Science Weed Science group are the ability to work in diverse groups of crops and noncropland areas, agronomic, forages, vegetables, turfgrasses, invasive plants, and highway rights-of-way in addition to cooperatively work with other researchers in disciplines involved with these areas such as agronomists, horticulturalists, soil scientists, foresters, environmental groups, regulatory officials, and basic scientists in plant biology, taxonomy, and genetics.
- The diverse agriculture of Georgia has lead to the weed science group having a national reputation in issues surrounding herbicide persistence to rotational crops whether they are from one agronomic crop to another or from agronomic crops to horticultural crops.
- In the past five years, the weed science research group has established a national reputation in issues surrounding herbicide resistant weeds and weed shifts that have occurred from intensive use of herbicide-resistant crops.

Evidence for research effectiveness and productivity and how this has changed over the past 7 years: CRSS research faculty have been extremely productive over the last 7 years. See the data tables at the end of this section for publications, grants, awards other indicators of research effectiveness. The following

impacts are examples of CRSS research faculty effectiveness:

- Released seven soybean cultivars
- Released 20 soybean germplasm lines
- Released one soybean mapping population
- Released eight wheat cultivars and co-released three wheat cultivars
- Co-released two oat cultivars
- Released 2 canola cultivars
- Released 7 peanut cultivars
- Released 3 vegetative and 1 seeded seashore paspalum cultivas
- Released 4 tall fescue cultivars
- Cotton fiber quality issued addressed: minimal effects of stand density on fiber properties; little to no effect of glyphosate application on fiber quality; significant influence of stink bugs on fiber properties
- Technology developed to support the release of MaxQ tall fescue. This is a technology that utilizes non-toxic, mutualistic *Neotyphodium* endophytes into tall fescue that provides benefits to plants but does not possess toxicity to livestock.
- Developed monoclonal antibody technology for the analyses for *Fusarium* head blight in wheat and barley and *Aspergillus* in peanuts.
- Corn producers have increased the use of conservation tillage from 18% to 38% conservation tillage.
- Vegetable growers have begun adopting late season corn production as additional means of profit and as additional means to participate in government farm programs.
- Increases in poultry litter utilization in grain crops have led to a reduction in conventional fertilizer use and improvement in production efficiency.
- Approximately 90% of the Georgia peanut acreage is planted following the UGA developed "Tomato Spotted Wilt Virus Risk Index".
- Yield and grade factors found to increase for peanut planted in the twin row pattern compared to a single row pattern. In the past 7-10 years peanut acreage planted in twin rows has increased from 20% to over 50%.
- An extensive monitoring network was established in 2005 to track the progress of the Asian soybean rust and 65% of Georgia's soybean acreage was treated with fungicides for this disease based on the monitoring data.
- Developed rapid assay to screen for salinity tolerance and other stresses in seeded seashore paspalum cultivars. Procedure will accelerate the development of marketable cultivars. This assay has been rapidly accepted on a world-wide basis.
- Emphasis on water conservation (water use by grass species/cultivar, alternative irrigation water use, cultivation practices, irrigation scheduling methods, etc.) have resulted in wide recognition of the UGA water program, including the Golf Course Superintendents Association of America requesting development BMPs protocols and training materials. The BMPs materials lead to the Georgia DNR allowing the GGCSA to operate under a BMPs protocol (based on our materials) rather than rigid regulations concerning times, days, quantities, etc. of water for irrigation. This is the first state to accept a BMPs approach for water conservation for the golf course industry or any turfgrass industry component.
- Research has shown the important role that phosphorus (P) plays in water quality. The research on the relationships between soil test P and P in runoff done by our faculty was part of a national project that convinced US EPA to require P-based nutrient management plans in large confined animal feeding operations (CAFOs). Our faculty also participated in the discussions that led to the development of state regulations that require P-based nutrient management plans for all poultry operations.

- Research has shown that land use practices strongly affect soil biological activity which, in turn, influences soil physical structure and organic matter accumulation, `especially in areas under conservation (e.g., no-tillage, forest) management.
- The economic impact of research that has led to critical use exemptions for herbicide use has been significant at around $100 million in benefit to Georgia growers per year.
- The research that has lead to obtaining Section 18 emergency herbicide registrations have had an economic benefit of approximately $1.5 million per year to Georgia producers.
- Research on glyphosate-resistant weeds and their management will mitigate the potential impact of $12 million per year in the cotton industry.
- Research on control of tropical spiderwort will mitigate the impact of a new weed that has increased control costs by 33%.

Weaknesses in research mission and how are these weaknesses being addressed:
Several challenges (weaknesses) confront the CRSS department. One of the biggest challenges is based on the fact that societal and institutional demands on our research programs continue to necessitate diversification. The diversity of CRSS research programs provides an opportunity to pursue new areas of science; however, as we diversify to meet the increasingly complex needs of our clientele and science, our core capacity within some of our disciplines has become critical (ie., the loss of one faculty member in some of our disciplines would preclude our maintaining research excellence). Having Crop and Soil Sciences faculty at all three locations provides CRSS faculty with an opportunity to effectively meet our state-wide mission; however, maintaining necessary interdisciplinary mix of faculty at all locations is becoming increasingly difficult. In addition to the relatively new teaching responsibilities, CRSS extension faculty have increasingly become involved in applied research. Some faculty are now responsible for teaching, research and extension. Although many faculty programs are strengthened by multi-functional responsibilities, time demands could result in compromising research quality. The interdisciplinary, multi-locational and multi-functional responsibilities exacerbates the problem of maintaining critical depth of research expertise within each discipline. These challenges will be further complicated as continued pressure is placed on state resources and faculty continue to supplement diminishing state resources with extramural funding. As extramural funding becomes a larger component of our budget, the department's ability to respond to local and state needs could be compromised as our faculty responsibilities will continue to gravitate towards the demands of granting agencies. Specific discipline based challenges follow:
- Need for a faculty position in warm-season turfgrass breeding. The department is working to create an endowed chair in this area
- Need for a faculty position in molecular genetics for turf and wheat breeding. The wheat breeding program has a Assistant Research Scientist addressing molecular genetics.
- The department did not refill a tenure track position in cotton breeding. A technical staff position was establishing and filled by a PhD scientist reporting to the cotton genomics member.
- Due to budget and/or time constraints, there has been a reduction in programmatic support from other departments that is critical to interdisciplinary research in CRSS
- Need for research in the area of nitrogen, phosphorus, and potassium use efficiency in conservation tillage systems. Filling the Cropping Systems position should address this issue.
- Need for a faculty position in peanut plant physiology.
- Net loss of three environmental sciences research faculty positions.The demographics of the environmental sciences faculty could result in significant loss in critical expertise unless younger faculty are hire over the coming.
- Being spread out over three campuses makes it difficult for the weed science group to pool

resources effectively
- Having one weed scientist on the Athens campus hinders graduate student recruitment and training to some degree.
- Need for a faculty position in invasive plant management.

How research is funded and how this has changed over the last seven years:
The need for research faculty to supplement state support with extramural funds has and will continue to increase. CRSS faculty have continued to increase the amount of both competitive and non-competitive external support. The need to support research programs with extramural funds will continue to escalate as state support declines and the cost of conducting research increases. The CRSS department will continue to balance competitive grants with non-competitive grants and contributions. This balance is essential as the non-competitive grants and donations to programs allows our faculty to focus on local problems, many of which are acute in nature.

How CRSS faculty are rewarded for research activities:
The majority of Department of Crop and Soil Sciences faculty have research appointments. Many faculty with 100% extension appointments also have active research programs. Evidence of research activity can include, but is not limited to, publications, authorship of books or chapters, abstracts, technical reports, presentations (either invited or voluntary), extramural funding, graduate student education and participation in professional societies. The faculty evaluation form (see appendix___) includes a complete list of research activities and how the amount and importance of these activities are used for the annual evaluation. Ultimately, research activity and the quality of research programs are a significant component of salary recommendations and a major consideration for the promotion and tenure and the post-tenure review process.

How underachieving CRSS research programs are encouraged to improve:
Faculty with official research responsibilities are required to maintain significant and high-quality research activities. If the level of research activity and/or the quality of the research program decreases below an acceptable level in accordance with the EFT assignment, the Department Head discusses the need to enhance research activities on an annual basis. If a research program is persistent in underachieving institutional expectations, this will be reflected in the annual evaluation. If a faculty member is underachieving and does not have tenure, this could ultimately affect the ability of him/her to achieve tenure and/or promotion. The post tenure review process (See Appendix___) is the procedure used for tenured faculty to ensure continued research quality The process for remediating underachievement is generally initiated after an unsatisfactory post-tenure review.

How research has affected the profession, industry, state, region, nation, and other constituents:
- Research in crop genomics has provided reference maps and associated molecular tools that are international standards for several of the crops including cotton, sorghum, sugarcane, peanut, and bermudagrass. These tools have been widely distributed and utilized to address a diverse set of topics ranging from fundamental questions in genetics and evolution, to identification of DNA markers needed to address specific local problems.
- Turf and forage bermudagrass, seashore paspalum, turf centipedegrass, and forage pearl millet cultivars are well-known worldwide and marketed through licensed growers located in the southern USA and in many foreign countries
- Cotton germplasm lines have been used to expand the genetic diversity of commercial cotton breeding companies
- Cereal genomics research has provided the resources for comparative mapping of the major grass crops
- Wheat cultivars have achieved a significant market share in the Southeast and in the Mid-South

- Glyphosate-tolerant soybean cultivars have achieved over a 60% market share in the Maturity Groups VII and VIII
- Peanut cultivars developed at UGA have achieved over 90% market share in Georgia and surrounding states
- DNA markers developed at UGA are being employed in a national program to enhance the oleic acid content of soybean seed
- The complete sequencing of the first 'tropical' (C4 photosynthesis) cereal, sorghum, will provide a model for most aspects of research and improvement of a wide range of crops and is reinvigorating private investments in this crop.
- Research determined the effects of stand density on fiber properties, little to no effect from glyphosate applications on fiber quality and that stinkbugs incluence fiber quality
- Georgia producers have dramatically changed planted cotton varieties over the past five years based on UGA research.
- Developed an endophyte detection system
- Georgia has become the lead state in developing the southeastern regional aflatoxin testing program in corn for publicly developed hybrids.
- Research in managing peanut for spotted wilt disease has lead to other peanut producing regions in the U.S. and other countries to follow our model of using a "risk index" for incorporating numerous components into a single management strategy. Other scientists are using the "risk index" model for managing other production related problems.
- Peanut research on rotation, tillage, row patterns, cultivar interactions, and plant growth hormones is utilized by most producers in the southeastern USA. Most other peanut regions, as well as peanut production in other countries have adapted the twin row pattern for planting peanut based on the results of our research.
- Asiatic soybean rust first appeared in the United States in the fall of 2004. An extensive monitoring network was established in 2005 to track the progress of the disease. As a result of the data from this monitoring network approximately 65% of Georgia's soybean acreage was treated with fungicides for this disease as a result of the monitoring effort.
- Research related to the seashore paspalum breeding program has contributed to rapid release of vegetative (3) and a seeded cultivar and rapid acceptance on a world-wide basis. Research contributions were in key areas of fostering salinity tolerance, wear tolerance, and low light tolerances, including defining stress mechanisms for the most tolerant ecotypes.
- Research on water conservation (grass species/cultivar, alternative irrigation water use, cultivation practices, irrigation scheduling methods, etc.) haas resulted in wide recognition of the UGA water program. The Golf Course Superintendents Association of America requested the development of BMPs, protocols and training material related to water conservation/water-use efficiency and salinity management. The BMPs materials led to the Georgia DNR allowing the GGCSA to operate under a BMPs protocol (based on our materials) rather than rigid regulations concerning times, days, quantities, etc. of water for irrigation. Georgia is the first state to accept a BMP approach for water conservation for the golf course industry or any turfgrass industry component.
- Irrigation research showed that water applied to turfgrass can be reduced by more than 50 percent if a wetting agent is used to reduce hydrophobicity of a water repellent soil.
- Commercialization of the variable rate center pivot irrigation system in six states.
- Research results showed that poultry litter is a major non-point source of phosphorus (P) to streams in northern Georgia and that it is causing eutrophication of reservoirs in this region.
- Research on stream water quality in pastures has shown that installing cattle crossings or water troughs can reduce time spent by cattle in streams and stream contamination with phosphorus, *E.coli,* and sediments. These results are now being used by the USDA-NRCS in support of cost-sharing the installation of cattle crossings and water troughs in pastures with unfenced streams.

- Research on ammonia volatilization from urea fertilizer in the forest environment has shown that significant losses occur and affect the forest floor and environmental conditions on the amount of ammonia lost from surface applied urea.
- Research on soil pH methodology for soil testing has resulted in the implementation of the routine measurement of soil pH in 0.01 molar calcium chloride solution to avoid the errors caused by differences in ionic strength of the soil solution. In addition, new procedure uses titration for measurement of soil pH buffering capacity, needed for making lime recommendations. Other soil testing laboratories (three in the southern region and one lab in the Midwest) are considering changing to these new methods.
- Procedures have been developed for mapping soil organic C in crop production fields using remote sensing techniques. Work continues with a scientist with VERIS corporation (Salina, KS) on mapping of soil pH, soil pH buffering capacity, soil organic C, etc in crop production fields using a field NIR Spectrometer.
- Water use analyses that used hydrologic models, GIS, real-time irrigation monitoring, and frequent field visits to farms over the state have provided state water agency and water user stakeholders with science-based planning for future water permitting activity. The recently completed Flint River Basin Plan and the soon to be released Coastal Zone plan use environmental monitoring data and analyses to help set permit action levels for regions as small as sub-watersheds.
- International conferences and field research on earthworm invasion biology, sponsored by UGA, USDA and NSF, have identified 1) the current and likely future geographic extent of earthworm invasions in North America; 2) mechanisms and pathways of invasions, and characteristics of invasive species; 3) impacts of earthworm invasions on soil processes and other organisms, both aboveground and belowground; and 4) possible means by which earthworm invasions might be mitigated, including regulatory intervention, appropriate land management, and increased public awareness of the problem.
- Production of methyl bromide, a broad-spectrum soil fumigant, is scheduled to be phased-out by the end of 2004. Commercial vegetable growers rely on methyl bromide for control of diseases, nematodes, and weeds, including Georgia's most troublesome weed complex yellow and purple nutsedge. The Weed Science group has evaluated many potential alternatives. Results from this work indicated that no single fumigant or fumigant combination would effectively replace methyl bromide. During 2002-2003, the Georgia Fruit and Vegetable Growers Association submitted six Critical Use Exemption (CUE) Packages written by the University of Georgia Vegetable Team. The Vegetable Team had to develop and provide scientific data on why Georgia growers could not survive without methyl bromide to request an extension for the use of methyl bromide. During the summer of 2004, the United Nations Environment Program agreed to grant all six of Georgia's CUE packages for the 2005 and 2006 seasons. It has been estimated the extension of methyl bromide use for just one year may be worth over $100 million to the Georgia vegetable industry.
- Glyphosate-resistant (Roundup Ready) cotton has readily been accepted by growers across the southeastern U.S. Greater than 89% of the cotton planted in Alabama, Florida, Georgia, North Carolina, and South Carolina is glyphosate-resistant. Heavy dependence on glyphosate has resulted in changes in weed species composition. Most notable and of greatest concern for Georgia producers is tropical spiderwort which is not effectively controlled by normal glyphosate use rates. The Weed Science team discovered and developed an effective management strategy for the management of this weed in Round-up Ready cotton production systems.
- Palmer amaranth is among the top three most troublesome weeds in Georgia cotton, peanut and soybean. The high growth rate of Palmer amaranth makes the weed extremely competitive in a multitude of crops. Cotton is currently the dominate agronomic crop in Georgia and is planted on 0.5 million ha with over 94% of the acreage being planted to Roundup Ready® technology. In

2005, a Palmer amaranth population in central Georgia was confirmed to be resistant to glyphosate. Since then, an additional 20 populations in central Georgia have been confirmed to be resistant to glyphosate. The weed team is developing a management strategy to deal with this new problem.

- Many athletic fields and golf course fairways are overseeded in the early fall with perennial ryegrass to provide an attractive playing surface for golfers during the winter and spring months. However, weed control, particularly annual bluegrass, is difficult to achieve due to the lack of selective management programs for this purpose. CRSS faculty have been evaluating and developing strategies for the control of annual bluegrass in overseeded golf course fairways for the past several years. Data from Georgia experiments was used to support a Special Local Need label request for the use of bispyribac-sodium (Velocity) for the postemergence control of annual bluegrass in overseeded bermudagrass fairways. The net impact is that as a result of this research conducted in Georgia, golf course superintendents and athletic field managers now have several herbicides that can be used to effectively control annual bluegrass in overseeded.
- Seashore paspalum is an environmentally-friendly warm-season turfgrass and is grown primarily in coastal regions of the southern United States. This grass has a low requirement for fertilizer and is adapted to saline sites. However, weeds can be a problem. Research conducted over the past three years by CRSS faculty have identified several herbicides that could be used for weed control in seashore paspalum. Information generated from this research is being supplied to agri-chemical companies who have proprietary rights for these herbicides. Companies will be able to use this information to register these herbicides for use on seashore paspalum.

How students are involved in CRSS research activities and how those relationships are formed and evaluated

Undergraduate students can become involved in research activities in various ways. Students can enroll in a special topics course and work on a one-on-one basis with faculty. Many times these courses will involve a research project. Students can also be hired as workers within a faculty member's program and get exposed to research activities. A college supported a program for CRSS provided faculty members with funding to hire students to get engaged in research activities. The participating faculty are required to submit a report on the student project. Several Crop and Soil Sciences faculty are active participants in the Young Scholars Program. This program provides high school students with an opportunity to work in a professor's program and get direct exposure to research activities.

	2000	2001	2002	2003	2004	2005	2006
Total Unit Research EFT				34.81	34.28	33.26	29.24
Refereed Articles*	157	152	131	135	181	179	
Books/Book Chapters*	69	31	45	63	41	38	
Scholarly & Invited Presentations*	148	90	106	102	132	78	
Invited Exhibits and performances*	27	28	43	16	23	21	
National/International Awards, Offices*	95	99	117	142	116	96	
Research Proposals Submitted	144	131	158	165	121	161	124
Research Proposals Funded	118	108	114	130	100	124	99
External Research Grant/Contract Expenditures					4,646,795	4,491,724	4,208,871
Various Account Expenditures					250,053	302,938	441,592
Royalty Account Expenditures					433,138	490,716	611,552
4-H Account Expenditures	22,304	93,467	123,567	134,677	194,851	101,190	116,071
%Faculty with external funding**	100%	100%	100%	100%	100%	100%	100%

Unless otherwise noted, all data calculated on a fiscal year basis

*Data reported on a calendar year basis

**All faculty have external funding either in the form of competitive grants, gifts, royalty,4-H or any combination.