2019 Annual Report of Accomplishments and Results

Tennessee
University of Tennessee Extension System (1862)
Tennessee State University Extension (1890)
Tennessee Agricultural Experiment Station/University of Tennessee AgResearch (1862)
Tennessee State University Institute for Food, Agriculture and Environmental Research (1890)

I. Report Overview

The NIFA reviewer will refer to the executive summary submitted in your Plan of Work. Use this space to provide updates to your state or institutions as needed.

1. Executive Summary (Optional)

Updates for 2019:

The University of Tennessee Institute of Agriculture has formally re-unified with the flagship UT Knoxville campus, resulting in a new reporting structure. The former UTIA Chancellor now holds the titles of Senior Vice Chancellor, reporting to the UT Knoxville Chancellor, and Senior Vice President for Agriculture, reporting to the UT System President. These changes will allow UT Extension and the Tennessee Agricultural Experiment Station/UT AgResearch (AgResearch) to better leverage resources across campus and the state, and to increase collaborations among faculty.

In April 2019, the University of Tennessee welcomed Dr. Hongwei Xin as Director of the Tennessee AES and Dean of UT AgResearch. Under his leadership, TAES/AgResearch is committed to meeting the goals and expectations set forth by the UT Institute of Agriculture Strategic Plan for 2018 – 2028.

AgResearch is the R&D driving engine for the Tennessee agriculture industry that contributes nearly $80 billion to the state's economy. Faculty conduct research on topics important to stakeholders to develop solutions that help them succeed. From variety testing and adoption by Tennessee farmers to environment-friendly biodegradable plastic mulch to value-added marketing opportunities, the administration and faculty meet the needs of the agriculture and forestry industries as part of UT's land-grant mission. AgResearch also invests in graduate and

undergraduate research opportunities to train the next generation of scientists. Last year, UTIA developed the USDA-funded program REACH to provide agro-industrial research experiences for community college students through paid eight-week fellowships.

AgResearch formally launched two new centers this past year. The Center for Agricultural Synthetic Biology focuses on agricultural sustainability by modifying DNA to create more sustainable agricultural products. The UTIA Genomics Center for the Advancement of Agriculture focuses on genomics and beef cattle, and seeks to advance agriculture by developing new strategies to increase productivity and improve sustainability of food production systems. In addition, the UT Institute of Agriculture partnered with The Nature Conservancy (TNC) on the Working Woodlands Agreement to address the grand challenge of climate change, the first partnership in the nation between TNC and an academic institution on the topic.

UT and TSU Extension extend the knowledge and expertise of the state's two land grant institutions to the 6.7 million people of Tennessee through agents and specialists in all 95 Tennessee counties. Our work is to provide education that produces solutions to societal, economic and environmental issues. Engagement of the state's citizens occurs where they live, work, and play through hundreds of programs which are planned, conducted, and evaluated by UT and TSU Extension. In FY 2019, Extension continued its leadership in economic development and outreach.

Extension Excellence in Economic Development: Extension's educational programs in 4-H youth development, agriculture and natural resources, family and consumer sciences, and community economic development produce substantial returns for Tennessee. Calculated by using research, questionnaires, observations, and sales records, Extension's estimated economic impact was more than $680 million for 2019. It was estimated that for every $1 in public funds invested in Extension, $9.31 was returned to the people of Tennessee in increased revenues, increased savings, and one-time capital purchases. The recurring economic impacts were estimated at over $430.4 million. These recurring economic values include increased revenues, increased savings, and one-time capital purchases associated with Extension programs in crop variety trials/pest control, forage systems, pesticide safety education, integrated pest management, turfgrass weed management, apiculture, and optimizing beef production. Using a UT System standard formula, an estimated 8,608 jobs were created or maintained because of the recurring economic impacts produced by Tennessee Extension. The one-time, non-recurring economic values were estimated at over $256.6 million from Extension programs in nutrition education, health literacy, financial management, volunteerism, and community service.

Extension's Excellence in Outreach: UT and TSU Extension professionals and the volunteers they recruited, trained, and managed made more than 4.13 million direct contacts through group meetings, onsite visits (farm, home, and workplace), phone calls, direct mail, and client visits to local Extension offices in FY 2019. In addition, indirect educational methods included mass media, exhibits, and Internet resources. Data for the Extension portion of this report utilized the Extension reporting system, System for University Planning, Evaluation and Reporting (SUPER). For the past 13 years, (2006-2019), this reporting system has been demonstrated to the administrators of 25 state Extension organizations who regarded it as a national model for Extension accountability.

II. Merit and Scientific Peer Review Processes

The NIFA reviewer will refer to your Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Process	Updates
1. The Merit Review Process	● Internal University Panel ● External University Panel ● Expert Peer Review The merit review and peer review processes established in the latest Plan of Work were implemented ten years ago. At that time, the external university panel review was completed with program planning and evaluation experts from Virginia Tech and the University of Maryland. This review panel found that the Tennessee Plan of Work was of exceptional quality. The panel's major suggestion was to continue a strong needs assessment and evaluation process focused on measuring substantial outcome indicators. The Plan of Work planned programs have only had minor changes since that time, therefore, an out-of-state review panel was not conducted in FY 2019.
2. The Scientific Peer Review Process	No updates. Please refer to Plan of Work.

III. Stakeholder Input

The NIFA reviewer will refer to your Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Stakeholder Input Aspects	Updates
1. Actions taken to seek stakeholder input that encouraged their participation with a brief explanation	In FY 2019, UT and TSU Extension made 7,232 contacts for needs assessment purposes.
2. Methods to identify individuals and groups and brief explanation.	92 advisory committee meetings for ANR, FCS, and 4-H, 95 open listening sessions, 216 focus groups, 3649 surveys, and 87 key information interviews in 2019. The newly formed UT Commission on Agriculture is comprised of key stakeholders from industry and commodity groups, the state government, the community, and senior leadership across the UT System. It holds public meetings twice per year to provide valuable feedback to UT leadership.
3. Methods for collecting stakeholder input and brief explanation.	The System for University Planning, Evaluation and Reporting (SUPER) tracks Extension's needs assessment efforts across Tennessee. In FY 2019, Extension conducted 216 different focus groups and 87 interviews with key informants.
4. A Statement of how the input will be considered and brief explanation of what you learned from your stakeholders.	No updates. Please refer to Plan of Work.

IV. Planned Program Table of Contents (Critical Issues)

26.	Developing Our Workforce

V. Planned Program Activities and Accomplishments

Please provide information for activities that represent the best work of your institution(s). See Section V of the Guidance for information on what to include in the qualitative outcomes or impact statements. Add additional rows to convey additional accomplishments. You may expand each row as needed.

No.	Title or Activity Description	Outcome/Impact Statement	Planned Program Name/No.
1.	Tennessee Variety Test Program for Corn Grain, Silage, and Soybeans	Tennessee producers continue to need information concerning the performance of corn and soybean varieties specific to their region. The variety test program provides data on varieties/hybrids that will optimize the profitability of Tennessee grain producers. The variety test program provides important information on which varieties perform most efficiently in Tennessee. Replicated variety tests were conducted on corn grain (90 hybrids; 14 brands), corn silage (6 hybrids; 2 brands), and soybeans (130 varieties; 17 brands) at seven of UT's Research & Education Centers located in the different physiographic regions of Tennessee in 2019. Data were collected on yield, quality, and agronomic traits. Results from these crop trials were compiled, along with results from the County Standard Tests (CST), and soybean disease variety trials and published in three peer-reviewed Extension publications. These results were distributed electronically on www.utcrops.com. Over 3,000 of these publications were distributed to farmers, extension agents, seed industry representatives, consultants and other interested clientele in Tennessee. In 2019, the variety test program provided an estimated $106.3 million in additional revenue to Tennessee producers. This number includes $44 million from corn and $62.3 million from soybean. These numbers were calculated by determining the monetary value of growing top performing varieties as compared to those varieties that exhibit average yield performance. Yield advantage was calculated by subtracting the test average from the average yield of top performing varieties. These were defined as varieties that did not differ statistically from the highest yielding variety within each test. In 2019, top-performing varieties exhibited a yield advantage of an additional 14 bushels per acre for corn and an additional 4 bushels per acre for soybeans. This number was multiplied by USDA reported price per bushel (corn: $3.88 and soy: $9.29) and Tennessee acreage harvested (corn: 920,000 acres and soy: 38 million acres) in 2019. Those results were then multiplied by 0.88 based on results from a 2017 survey, which indicated 88% of respondents use the variety test results to select top performing varieties.	Supporting Food, Fiber, and Energy Systems

		By helping producers distinguish between top-performing and average or poorly adapted varieties, the Tennessee variety test program provided an estimated $106.3 million ($44 million from corn, $62.3 million from soybean) in additional revenue to Tennessee row crop producers in 2019. The variety test program has a significant economic impact to Tennessee and continues to be a program that is highly valued and supported by Tennessee producers.	
2.	UT Extension Beef Cattle Programs	Tennessee's beef industry plays a vital role in the state's economy. Cattle are produced in every county in Tennessee and have greater economic importance in the Middle and East Tennessee regions. Challenges facing the beef cattle industry in Tennessee range from the adoption of very basic management practices to complicated global market drivers that affect input costs. Nutritional, reproductive, genetic, and health management are the general areas that impact profitability most. In response to these challenges, UT Extension Beef Cattle Programs, led by UT Extension Specialists in the Department of Animal Science and delivered by UT Extension County Agriculture/Natural Resource (ANR) Agents, provided production consultation and educational curriculum to Tennessee beef cattle producers. These programs continue to strengthen animal systems in Tennessee. Programming included Tennessee Master Beef Producer, Tennessee Beef Quality Assurance, Tennessee Central Bull Testing, Tennessee Beef Heifer Development, UT Bovine Reproductive Management Training, UT AgResearch field days, on-farm demonstrations, and field research. Extension Specialists in the Department of Animal Science also provided thirteen in-service trainings to UT Extension ANR County Agents to ensure they are prepared to quickly and appropriately respond to clientele questions and consultation needs. Producers, veterinarians, and others associated with the beef industry were the target audience for the planned programs with beef cattle. Tennessee cattle producers are primarily cow-calf operators. The Master Beef Producer program is a series of 12 educational sessions for Tennessee beef producers. These sessions include hands-on demonstrations, mini lectures, discussions, question and answer sessions. The program is designed to enhance the profitability and competitiveness of cow-calf operations through essential, technical information that includes a detailed beef production manual and the opportunity for producers to interact with trained facilitators and to share ideas with other producers. The	Supporting Food, Fiber, and Energy Systems

		Tennessee Beef Heifer Development Program is to incentivize the repopulation of the beef herd through custom heifer development. This can be accomplished by the implementation of management practices with access to more productive replacement females allowing for more rapid expansion of Tennessee's beef herd. This will improve the longevity of these females, decreasing turnover and providing for exponential improvement in genetics and associated revenue generation. Producers can visit www.utbeef.com for more information on Tennessee's program offerings. As a result of the UT Extension beef cattle programs, 106 UT Extension Agents and Specialists spent 29,289 hours conducting educational programs that reached 181,802 direct contacts. Best management practices in beef cattle production were taught at 1,850 group meetings, 2,024 on-site visits and 4,938 walk-in consultations in the local county office. Reach and impact, as measured by direct contacts, remained relatively stable compared to 2018 in all categories reported. Mail, telephone and electronic communications reached 91,097 contacts. These direct methods were reinforced by 811 social media posts, 263 newspaper articles, 107 radio programs and 6 television programs reaching an estimated 20.8 million indirect contacts. Volunteers invested 1,437 hours of their personal time to establish a total of 20,826 direct and indirect contacts. As a result of the beef programs offered by UT Extension, there were 3,596 beef producers who sold 123,362 calves that were managed for improved marketing methods. Tennessee producers utilized 4,044 bulls (through natural service or artificial insemination) with greater genetic potential to produce 87,788 head of calves to increase returns by $4,389,400. 2,413 beef producers implemented reproductive management by conducting breeding soundness exams on 3,779 bulls ($18,895,000 increased returns) and pregnancy diagnosis on 232,385 cows/heifers ($92,954,000 increased returns). UT Extension beef programs had a $116.24 million economic impact to our state in 2019.	
3.	Forage Educational Impacts on Livestock and Forage Producers	Forages are grown on over 3 million acres in Tennessee, and impact over 40,000 livestock operations across the state. Producers need research-based information on improved production practices to maintain economic and environmental sustainability.	Supporting Food, Fiber, and Energy Systems

		In response to the need of providing Tennessee producers with research-based information, UT Extension conducted educational forage programs that reached over 37,000 direct contacts during 2019. Our target audience for this program is Tennessee livestock and forage producers. Stockpiling tall fescue and weed control, as well as adding clovers to grass pastures, and utilizing warm-season forages were the primary educational topics covered. These were taught through approximately 200 group meetings and almost 800 on-site visits. These direct contacts were supported by 140 written articles and 25 radio programs. Extension's forage programs resulted in 72,000 acres being planted with clovers, 27,000 acres planted to warm-season grasses for summer forage production, and 39,000 acres of tall fescue stockpiled to decrease winter feed costs. Over 229,000 acres of forage crops were treated to decrease weed pressure. The increase in forage profitability from these practices were significant. Based on data from research studies, the fertilizer savings from planting clovers was $2.1 million. The improved forage production from warm-season grasses is valued at $500,000. The stockpiling of tall fescue saved $1.5 million in feed costs. Weed control improved forage production by approximately $9 million. The total impact of the educational forage programs for Tennessee is valued at $13.1 million.	
4.	Tennessee Extension (UT/TSU) Master Gardener/Residential and Consumer Horticulture	Estimates nationally are that 74% of all households participate in indoor and outdoor lawn and garden-related activities and spend a reported 36.9 billion dollars within the do-it-yourself horticulture industry (2016 National Garden Survey). Based on United States Census data, 74% of households represents 1,866,431 households and 4,969,828 citizens in Tennessee. The average spending in lawn and garden areas was just over $500.00 per household (2017 National Garden Survey). These numbers provide a perspective on the size and economic impact of stakeholders within residential and consumer horticulture. Specific needs include proper site and plant selection, fertilizer and pesticide use in residential landscapes, vegetable and fruit production, and demonstrating practices that conserve valuable soil and water resources. The continued steady growth in food gardening and involvement by millennials illustrate the critical need for investment in technology and up-to-date educational resources.	Supporting Food, Fiber, and Energy Systems

		In 2019, Tennessee Extension (UT/TSU) personnel supported consumer horticulture education and led nearly 40 local Tennessee Extension Master Gardener (TEMG) programs totaling 43,154 hours for Extension personnel. Our Extension program focuses on conducting in-person as well as digital horticulture education in addition to publications and training materials that delivers practical and research-based information to consumers in Tennessee. These educational programs and products are delivered by Extension agents, specialists and Extension Master Gardener volunteers. These responses are supported, led, and facilitated by the Residential and Consumer Horticulture Leadership Team as well as the Master Gardener Workgroup, the Sustainable Landscapes Workgroup and the Home Fruit and Vegetable Workgroup. The specific outcomes as related to the Master Gardener Workgroup and Home Fruit and Vegetable Workgroup efforts are reported in this impact. In 2019, there were 354,127 direct contacts made by Tennessee Extension (UT/TSU) agents, as well as state and area specialists and TEMG volunteers in the area of residential and consumer horticulture. These contacts include group meetings and demonstrations (95,872), office visits (12,939), on-site visits (33,260) as well as phone calls and emails (212,056). Additionally, 11,506,312 indirect contacts were made through print, television, radio, social media and other methods. Home fruit and vegetable production is a key area of educational emphasis and need in Tennessee. In 2019, there were 15,559 direct contacts in the area of home fruit and vegetable. Of these, 2,492 attended training classes or received instruction on home fruit and vegetable production and increased their knowledge of crop, cultivar, and site selection; soil and fertility management; cultural practices; plant management practices; pest and disease identification; integrated pest management practices; or proper harvest and handling by an average of 74%. TEMG volunteers contribute substantially to the overall horticulture education and outreach capacity within Tennessee Extension. Each year intern Extension Master Gardeners complete an initial training course that prepares them for ongoing service and education in horticulture across the state. In 2019, 575 Extension Master Gardener interns received 40 hours of training and increased their knowledge by an average of 78% in plant and soil science principles; landscape design, selection, and maintenance; pest and disease control (Integrated Pest Management); fruit and vegetable production; and environmental stewardship of water and soil resources. Specifically, within the Tennessee Extension (UT/TSU) Master Gardener program, volunteers provided these impacts for the state:	

		• TEMGs managed 140 landscape and ornamental gardens to demonstrate sustainable practices; • TEMGs managed 51 food gardens that contributed 68,520 pounds of produce to local citizens and communities; • TEMGs participated in or led 405 community events, such as fairs, festivals, and garden show that reached 979,942 residents; • TEMGs taught or conducted 546 educational presentations that delivered information to 13,953 residents; • TEMGs led or participated in 106 camps, garden clubs or agriculture events that reached 11,184 Tennessee youth; • TEMGs answered 5,954 helpdesk or helpline questions to supply horticulture information to residents; and • TEMGs had 2,932,585 contacts through websites and social media sites including Facebook and Instagram. Extension Master Gardener volunteers provide value to Tennessee through educational outreach and serve in horticulture. In 2019, there were approximately 2,702 volunteers reporting 200,003 hours of service in consumer horticulture education in Tennessee that is valued at $4,534,068.01 (Independent Sector).	

5.	Commercial Fruit and Vegetable Production in Tennessee	The challenges facing the commercial fruit and vegetable industry include implementing food safety practices, integrated pest management, organic and sustainable cultural practices, season extension, and profitability. Through educational programming, UT/TSU Extension provides the latest information to our producers on meeting the regulatory requirements of the Food Safety Modernization Act (FSMA), developing integrated pest management programs, reducing off-farm inputs, and extending their cropping season with the use of high tunnels and greenhouses. UT/TSU Extension programming in fruit and vegetable production resulted in over 32,500 direct contacts during 2019. Best production and management practices were taught at 325 group meetings and 645 on-site visits. Over 1,500 social media outlets, radio programs, TV stories, newspaper articles and other publications reaching 2,930,961 stakeholders supported the direct contacts. Moreover, 199 fruit and vegetable producers implemented best management practices including site selection and development, variety/rootstock selection, pest/disease/weed identification, effective pesticide use, soil/plant tissue testing, research-based fertilization, and proper post-harvest handling. While 230 fruit and vegetable producers adopted good agricultural practices (GAPs) on 10,691 acres to improve food safety and enhance marketing opportunities. The total economic impact of Extension's commercial fruit and vegetable horticulture programming was estimated at $173,320 in increased savings, increased income, and one-time capital purchases by adopting good agricultural practices (GAPs), season extension or organic production practices.	Supporting Food, Fiber, and Energy Systems
6.	TSU, Tennessee New Farmer Academy:	TSU's Tennessee New Farmer Academy for Farmers, Ranchers and Returning Veterans is a seven-month certificate program designed for those with an interest in becoming agricultural entrepreneurs. Ideal candidates for this program include those who are new to	Supporting Food, Fiber, and Energy Systems

	7-Month Certificate Program offered at 3 locations (Memphis, Nashville, and Wartburg, TN)	agriculture, those who wish to transition into agriculture from another field such as military service or private sector work, or those who are looking for a post-retirement opportunity. The program focuses on teaching the concepts, providing the information, and facilitating the hands-on experience needed to build solid, viable, and successful agricultural businesses. TSU Extension started this program in 2016 to address the aging farm operators across this country and to fill the vacuum left by retiring farmers and land owners. In 2019, this program graduated 104 new farmers and ranchers and returning veterans for farm ownership and operation.	
7.	Development of Novel Tools for Agricultural Synthetic Biology	Synthetic biology is a growing field that combines engineering and biology to produce new or improve existing biological materials. Nanomaterials of plant origin are a relatively understudied area of biotechnology with wide potential for agricultural implications, such as optimizing traits in crops. More research is needed in plant nanomaterials to realize the full potential of this area, but for some scientists, the cost of research and a lack of tools prohibit them from conducting experiments. Researchers at the University of Tennessee developed MoChlo – a modular chloroplast cloning system that allows scientists to engineer chloroplasts in plants. It includes 128 standardized chloroplast-specific parts and chloroplast-specific destination vectors. The journal *Plant Physiology* highlighted this technology in March 2019, thus increasing the awareness of the toolkit within the scientific community. MoChlo is available for purchase at minimal costs from the nonprofit plasmid repository Addgene. The UT research team hopes this will lead to a change in action as more scientists, including those with limited resources, have access to this tool which can help them engage in synthetic biology for agricultural purposes and to train students and other scientists in biotechnology.	Supporting Food, Fiber, and Energy Systems
8.	Improving Frozen Foods	The frozen food industry is a multi-billion-dollar enterprise and thus plays a significant role in the global economy. Advantages to frozen food include food preservation, access, and convenience. Yet the formation of large ice crystals as a result of ice recrystallization plagues the frozen food industry and threatens customer satisfaction. Naturally existing ice recrystallization inhibitors are neither readily available nor cost-effective; other options such as sucrose and sorbitol have a negative resonance with consumers who fear they are	Supporting Food, Fiber, and Energy Systems

		unhealthy additions to the food. Ice recrystallization inhibitors that are abundant, cost effective, and that elicit a positive response from consumers is important to the frozen food industry. Researchers at the University of Tennessee have discovered a novel group of ice recrystallization inhibitors derived from cellulose biomass, a natural and abundant biopolymer. The cellulose biomass has potent ice recrystallization activity that may change how the frozen food industry combats ice crystal problem in a way that is cost-effective and accepted by consumers. Further changes may include the public health sector and how it freezes living cells, tissues and organs for preservation.	
9.	Relevance of Genetics to Mastitis in Dairy Cows	Mastitis represents the most common infectious disease impacting the health and well-being of dairy cattle worldwide. This disease has a number of downstream impacts that include: lowering cattle productivity, farm profit margins, dairy product yields, and product stability, while being the number one reason for antibiotic use on US dairies and increasing the risk of foodborne illness. Current strategies to limit mastitis are effective at reducing the majority of infections. These strategies include providing clean, dry, comfortable environments for cows, use of sanitary practices to limit the spread of infection while harvesting the milk, sanitary disinfection of milking equipment, and boosting the immune system of the cow through vaccination and genetic improvement. Despite these strategies, mastitis remains widespread and potentially devastating. Researchers at the University of Tennessee have studied cows' DNA to better understand why some cows are affected by mastitis while others are not. The team exposed dairy cows to the bacteria Streptococcus uberis, a common cause of mastitis. They identified genetic variations in the cows' DNA that partly explained the strength and duration of bacterial presence in the milk of dairy cows that were exposed to Streptococcus uberis, and thus why some cows are better able to eliminate the pathogen. This and future studies will increase our knowledge pertaining to the relevance of genetics and immune processes that contribute to mastitis resistance in order to help reduce the impacts of this disease.	Supporting Food, Fiber, and Energy Systems

10.	Control of Invasive Insects in Ornamental Crops in the Southern United States	The nursery and greenhouse industries are important employers in many rural and underdeveloped communities, providing over 2 million jobs and close to a $120 billion economic impact in the US. Pest and disease damage are the principal sources of nursery industry revenue loss. Japanese beetle is an invasive pest and is under a government-mandated quarantine program that requires expensive treatments to ship the millions of nursery plants produced each year. Other insects like flatheaded borer are not subject to quarantine, but can cause extensive losses in production. Research performed at the Tennessee State University Nursery Research Center has developed lower-cost control options for invasive pests to benefit nursery growers. New insecticide chemical classes that are reduced-risk for farm labor, the environment, and pollinators are being tested for effectiveness in nursery pest management for Japanese beetle and flatheaded borer. Biological control methods also are being developed to lessen the impact of Japanese beetle. As a result of this project, costs for Japanese beetle control were reduced between $109 to $738 per treated acre over existing treatment options in the U.S. Domestic Japanese Beetle Harmonization Plan. For flatheaded borer, research supported a 50% reduction in the insecticide rate for flatheaded borer management, cutting grower costs in half and reducing environmental contamination. Additionally, growers are obtaining three years of flatheaded borer protection from a new single drench treatment, which reduces labor 5-fold over traditional trunk spray treatments that are applied twice a year.	Supporting Food, Fiber, and Energy Systems
11.	New Antiviral Tools from Natural Defensive Molecules in Livestock	Viral diseases cause billions of dollars in annual losses to livestock production in the US. In addition to the threat to animals, we have seen the devastating effects when viruses jump from animals to humans as is the case with zoonotic viruses such as SARS and the COVID-19 coronavirus. Despite the magnitude of these problems, there is a lack of effective vaccines and antiviral treatments for veterinary and human uses. Scientists at Tennessee State University have addressed this issue by searching for antiviral molecules that exist naturally in the wild, especially in livestock animals. These compounds, including those called natural immune interferons, have adapted over time to confront ever-changing viral threats. Scientists centered their search on the omega type of immune interferon from pigs and cattle. These types of interferons have received relatively little attention in the search for new	Supporting Food, Fiber, and Energy Systems

		weapons to fight viral diseases. Pigs and cattle have a much greater number of omega immune interferons than humans do, and generally show a much greater antiviral activity than the most commonly studied interferon types. Omega type interferons were isolated from pigs and cattle and refined using bioengineering procedures. Several of the interferons have shown superior antiviral activity in laboratory tests. Some of them have broad activity to fight viruses not only in pigs, but potentially in humans as well. In cell and tissue-based tests, several of the new omega interferon molecules have 100 to 1,000 times greater activity than the conventional interferon alpha type. These new interferon molecules are now being released for use in research applications and a process has been initiated for animal tests and antiviral development.	
12.	Controlling Nursery Insects Without Pesticides	Woody ornamental nursery production contributes millions to the United States economy each year. High value deciduous trees such as maple, dogwood, redbud and others are susceptible to a trunk boring beetle known as the flatheaded appletree borer which is a major pest that can destroy entire fields of newly transplanted trees. Currently, the best preventative treatment for flatheaded appletree borer management in newly transplanted nursery and landscape trees includes a soil drench of neonicotinoid class pesticide to protect trunk tissue from borer damage. However, there are concerns about the effects of this chemical class on pollinators as well as the selective pressure that can be placed on flatheaded borer populations if only one pesticide class is used for management. Research at the Tennessee State University Nursery Research Center observed that the presence of weeds in nursery tree rows resulted in fewer flatheaded appletree borer attacks when compared to tree rows kept clean with herbicides. This observation led to a project using cover crops to protect high value trees from flatheaded appletree borer damage following transplant. In the first year of a two-year test, wheat and crimson clover cover were planted in nursery tree rows based on the knowledge that wheat would be at the proper height to protect the tree trunks when the borers were active in spring. The crimson clover was added as a nitrogen source. In the second year, annual ryegrass and crimson clover were planted, again with the knowledge that the ryegrass would reach an appropriate height by the spring borer season. The second crop combination senesced faster than the wheat and appeared to have been more effective at suppressing summer weeds.	Supporting Food, Fiber, and Energy Systems

		Winter cover crops grown at the base of newly transplanted red maple trees protected them from flatheaded appletree borer damage, while also effectively managing weeds. The presence of the cover crop reduced borer attacks by 95 percent in the first growing season following transplant. The results could be useful for orchards, nurseries, urban landscapes and agroforestry producers in managing this significant economic pest. Trees grown in the cover crop did have reduced growth, as expected given the competition with the cover crop for water and nutrient resources at the base of the tree. Research is underway to minimize the amount of reduced growth.	
13.	Crop Nutrient Stewardship	In 2019, Tennessee producers continued to encounter low crop prices, increasing prices of nitrogen (N) and phosphorus (P205) fertilizers, and the contribution of production agriculture to diminished water quality in the Mississippi River Basin, fertility practices need to be reevaluated to better benefit our producers and the environment. UT Extension's Crop Nutrient Stewardship workgroup has implemented programs to increase the use of sustainable resource management practices. These practices enable the world to meet present needs while continuously improving future generation's ability to meet their own needs. This can be done by lessening our environmental impacts, enhancing human health, and improving the economic and social well-being of Tennessee's communities, but also by increasing productivity to meet food, fuel, and fiber demands. TSU Extension faculty developed a digital diagnosis method to identify plant nutrient deficiency to assist farmers and extension agents. Tennessee 4-H youth were trained on judging soils and identifying nutrient concerns by UT and TSU Extension faculty and Extension agents. In response to these challenges, an integrated, multi-disciplinary research, education, and outreach program has been established to develop and disseminate information pertaining to crop fertility practices and the associated economic and environmental impacts. UT Extension's Crop Nutrient Stewardship workgroup promoted the adoption of profitable and environmentally-conscious resource management practices through presentations at field days, county, and/or on-farm demonstrations, newly-developed publications and/or mass media articles, and on-site visits. The target audience for this program includes agricultural producers, environmental scientists, and regulatory agencies.	Enhancing Biodiversity and Environmental Quality

		By assessing nutrient needs through soil sampling and analysis, 1104 producers potentially reduced fertilizer costs by $17.60/ac and 7,700 tons of excess P2O5 from potentially moving offsite and causing environmental degradation on over 408,000 row crop acres. By utilizing UT fertility recommendations on approximately 171,000 acres, 772 producers had a potential reduction in P2O5 fertilizer costs of $15.50/ac as well as more than 15,800 tons of P2O5 that could move offsite and have negative environmental consequences. UT Extension Crop Nutrient Stewardship workgroup programing had an economic impact of over $9.8 million to Tennessee's agriculture economy.	
14.	Tennessee Master Logger Program	Training of loggers in Best Management Practices (BMPs) is necessary in providing a non-regulatory approach to protecting water quality during forest harvesting operations in concordance with the Clean Water Act. The Tennessee Master Logger educational program is a cooperative effort between UT Extension, Tennessee Department of Agriculture Forestry Division, and the Tennessee Forestry Association. In response to this need of trainings, over 3650 contact hours were reported. UT Extension conducted 12 continuing education logger workshops with 294 participants (loggers, foresters, landowners) in 2019 (8 hours each). UT Extension held 3 logger workshops of 5 days each for 37 participants (loggers) in 2019 (36 hours of instruction). Each participant increased their knowledge on BMPs to protect water quality during harvesting operations during the one-day continuing education workshop. Approximately 50% of the trained logging work force in Tennessee attended the workshops (requirement to maintain Master Logger designation is to attend one continuing education workshop every two years). Based on previous BMP implementation survey results, renewed educational emphases were placed on wetlands, stream crossings and water quality associated with water bars and skid trails during continuing education sessions. Derived from the Master Logger class, each logger is estimated to harvest 500 acres per year, averaging 3,000 board feet per acre (partial harvests included), and with an estimated average timber value of $1,000 per acre. The Tennessee Master Logger educational program has reached more than 1,200 loggers and 300 forestry professionals since 1983 or about 90 percent of the state logging workforce.	Enhancing Biodiversity and Environmental Quality

15.	Evaluating the use of Plastic Biodegradable Mulch (BDM) among Tennessee Fruit and Vegetable Producers	Polyethylene (PE) mulch is traditionally used in the production of fruits and vegetables because of the benefits it provides in terms of soil moisture and temperature conservation, weed control, increase yield and crop quality. Regardless of the benefits this mulch offers, there are concerns regarding the environmental sustainability associated with the use of PE mulch because of its contribution to soil plastic pollution. Soil plastic pollution has long-term impacts on soil health, yield, and farm profitability. Plastic biodegradable mulches (BDMs) are a more sustainable alternative to PE mulch as they provide similar benefits to PE mulch, but at the end of the cropping season they do not have to be removed, but rather they are tilled into the soil, as they are designed to be decomposed into water and carbon dioxide in soil conditions. If BDMs are more environmentally friendly than PE mulch, why are fruit and vegetable growers not using them? To better understand the factors associated with the adoption of BDMs among Tennessee fruit and vegetable growers, a team of research and extension faculty at the University of Tennessee evaluated the economic feasibility of adopting BDM, and assessed the factors influencing the use and willingness to pay for BDM among Tennessee fruit and vegetable farmers. Findings from this research suggest labor costs associated with the use of PE mulch, the price of BDM compared to PE mulch, and farmer environmental stewardship are the most critical factors in determining the economic feasibility of adopting BDM and farmers' willingness to adopt this type of mulch. The team shared their research results with producers and extension professionals, aiming to increase fruit and vegetable farmers' knowledge of BDM, and the factors influencing the economic feasibility of adopting this mulch. This new knowledge may lead to a change in action as producers make informed decisions about transitioning from PE mulch to BDM. The team also shared their research results with manufacturers, input suppliers, and policymakers to help them better assess market opportunities, and possible incentives to promote the use of BDM among Tennessee fruit and vegetable producers. This increased knowledge may lead to a change in action as input suppliers increase the availability of BDMs in Tennessee based on market potential, and policymakers assess strategies to reduce plastic pollution associated with the use of PE mulch by providing economic incentives to increase the adoption of BDMs among Tennessee fruit and vegetable farmers.	Enhancing Biodiversity and Environmental Quality

16.	Value-Added Agriculture, Direct Marketing and Agritourism	More and more Tennessee farmers are considering farm-based and value-added enterprises. On farm processing, packaging, direct marketing and agritourism are becoming routing enterprise considerations by farmers. As new value-added and direct marketing enterprises are considered across the state, the need for information, assistance, and training increases as well. The 2017 Census of Agriculture for Tennessee reported that the value of farm products, including value-added products, produced and sold for human consumption was more than $38.8 million from 3,773 farms. The value of food sold by farms direct to retail markets was more than $30 million by 458 farms. The merit of value-added agricultural products was more than $16 million by 757 farms. The value of agritourism and recreational sales was more than $15.5 million from 644 farms These producer entrepreneurs face many challenges in analyzing and developing enterprises including business planning and management, market planning and implementation, risk assessment and management, and understanding and abiding by regulations. The economic impact of farms in these enterprise types can be increased through educational programs. In 2019, educational efforts in value-added agriculture, direct farm marketing and agritourism by county agents and state specialists reached 6,182 total contacts through direct methods including 208 client visits to Extension offices, 93 on-site visits, 1,041 direct mailings or phone calls and 259 group meetings. In addition, more than 90,833 indirect contacts were made through educational exhibits, news articles, social media, radio programs and other indirect methods. Major educational programs offered by Extension and industry partners in 2019 included Value-Added Beef Marketing Regulation Workshops, Food for Profit Workshops, Better Process Control Schools, Domestic Kitchen Training, Online Marketing Webinar Series, Business Planning Workshop Series, Farmers Market Vendor Boot Camps, and Value-Added Dairy Workshop. UT/TSU Extension faculty and agents trained and mentored farmers to sale their produce by direct marketing to consumers either through farmers' markets, Community-Supported Agriculture (CSAs) or on farm markets.	Enriching Our Economy

		Through Extension programming in 2019 the results of the program are reported: • 252 participants reported gaining knowledge or skills to increase sales revenue, reduce costs, prevent losses, increase payroll or make one-time capital purchases through value-added agriculture, direct marketing and/or agritourism; • 150 participants reported increasing knowledge of marketing fundamentals, tools and techniques; • 146 participants developed goals for implementing marketing strategies; and • 54 participants reported increasing their understanding and skills needed to analyze and develop a food manufacturing business. Value-added agriculture, direct marketing and agritourism enterprises contribute to the sustainability of Tennessee farms and rural economies. UT Extension programming for participants helps improve their potential for success by increasing knowledge and skills needed to analyze, develop, improve and/or expand value-added agriculture, direct marketing and agritourism operations.	
17.	Fresh Starts Through Bankruptcy Counseling and Debtor Education	Bankruptcy represents a last resort for consumers in financial distress allowing them to pay off debt with certain court protections (Chapter 13 Bankruptcy) or to liquidate assets to discharge debt (Chapter 7 Bankruptcy). For many facing bleak financial situations – such as credit overextension, unemployment, illness, disability, death of a family member, divorce – bankruptcy offers the hope of a new start. After reaching a peak during the Great Recession, personal bankruptcies have been decreasing across the United States. However, personal bankruptcy rates still remain high in the South. In 2018, Tennessee had the second highest bankruptcy rate in the nation with 33,877 bankruptcy filings or 5 filings per 1,000 residents. Shelby (10,122 filings), Hamilton (2,203 filings), and Davidson (2,048 filings) led the state in bankruptcies. In response to those statistics for Tennessee, pre-bankruptcy counseling and post-bankruptcy education are required of all individuals filing for either Chapter 7 or Chapter 13 bankruptcy. UT Extension Family and Consumer Sciences is an approved provider for bankruptcy counseling and education. Ten Extension agents across Tennessee and one financial readiness counselor stationed at Fort Campbell offer bankruptcy counseling and education. In 2019, 7	Enriching Our Economy

		individuals were reached through pre-bankruptcy counseling and 779 individuals were reached through post-bankruptcy education. High quality financial education can serve as a buffer against personal bankruptcy aiding families in using credit wisely and offering families resilience in the face of financial hardships. In 2019, Extension agents across the state were engaged in offering financial education with agents logging a total of 16,516 hours in financial education programming with 4,086 additional hours logged by volunteers. 91,061 total direct educational contacts were made by agents and volunteers through group meetings, programs, and other direct methods. An additional 1,431,202 Tennesseans were reached with the message of the importance of savings and financial responsibility through agent and volunteer media and exhibits. Among the most successful learning and behavioral outcomes for adults participating in financial education programs were: 99.19% (1,726 participants) set savings goals and/or enrolled as a Tennessee Saver. 96.26% (561 participants) became more aware of the importance of starting to save and invest early in life. 93.98% (216 participants) felt more confident that they could build wealth. 92.15% (4,627 participants) better understood credit reporting and scoring. 96.62% (n=6,006) learned the difference between wants and needs. Three months after participating in a financial education program, 90.04% (3,795 participants) followed a spending plan. 87.71% (4,175 participants) tracked their spending. The percentage of Extension clientele reporting a savings account rose to 78% in 2019 from 28.3% in 2018. The percentage of clientele reporting debt reduction increased from 63.4% in 2018 to 72% in 2019. The estimated economic impact of clienteles' savings totaled approximately $1,135,800, with debt reduction estimates totaling approximately $895,488. The total estimated impact of Consumer Economics programs on Tennesseans' saving increase and debt reduction was $2,031,288.	
18.	Implications of the US-South Korean Free Trade Agreement on U.S. Beef Exports	U.S. agriculture is dependent on the international market with significant implications on the U.S. economy. It is important to understand the impacts that trade agreements have on U.S. agriculture and the economy to better inform both policy makers and agribusiness. South Korea is the top six markets for U.S. agricultural exports in 2017, likely attributed to the US-South Korean Free Trade Agreement (KORUS) which is intended to increase U.S. agricultural	Enriching Our Economy

		exports to South Korea and be a potential model for making free trade agreements with other Asian countries. A University of Tennessee research team conducted a quantitative analysis to evaluate the competitiveness of U.S. beef in South Korea and assessed how KORUS impacted preferences for imported beef products by exporting source (USA, Australia, and the rest of world). Researchers found evidence of limited competition across exporting countries, as well as a habit formed for U.S. beef and an increased preference for U.S. chilled beef since the implementation of KORUS. This indicates the success of KORUS for the U.S. beef industry and underscores the critical desire to maintain this agreement. The UT researchers have shared these results with policy makers at the USDA and with Tennessee cattle producers' groups to enhance their knowledge of the potential impact of policies or regulations on marketing beef products. This information may help U.S. producers and agribusiness to identify potential markets and make more adequate investment decisions. Enhancing the knowledge of policy impacts on trade could also help producers and investors reduce the uncertainties and risk of counting on a single/dominant market and make a more comprehensive and long-term investment plan. In the long term, this study could benefit society by developing a stronger agricultural sector through the improvement in the decision process and related financial condition of U.S. agricultural producers and agribusiness. Consumers will benefit from acquiring low-cost and diverse agricultural products when producers and agribusiness gain more knowledge in allocating resources more effectively.	
19.	EFNEP and TNCEP: Improving dietary and physical activity behaviors for limited-resource Tennesseans	Poor dietary quality and lack of physical activity continue to plague limited-resource Tennessee adults and youth. Increased incidences of diet-related chronic diseases such as diabetes, hypertension and certain cancers are prevalent among this population. Childhood obesity is also a factor to consider for limited-resource Tennesseans. Access to healthy food options and physical activity opportunities, along with nutrition education programming and community interventions, are important for helping limited-resource individuals and families reduce health risks while managing food resources effectively. Through the Expanded Food and Nutrition Education Program (EFNEP) and the Supplemental Nutrition Assistance Program Education Tennessee Nutrition and Consumer Education Program (SNAP-Ed: TNCEP), UT/TSU Extension Family and Consumer Sciences continues to	Strengthening Our Health

		offer nutrition education programming and interventions for limited-resource audiences. The primary objectives of these multi-level, community health programs and interventions were to increase the likelihood that limited-resource persons would make healthy food choices within a limited budget and choose physical activity guidelines consistent with the current Dietary Guidelines for Americans. Youth from preschool to high school and adults from young adulthood to seniors benefited from this work. 33,292 adults and youth were reached through direct education programming offered through EFNEP and SNAP-Ed: TNCEP. 2,401,454 adults and youth were reached through in-direct educational efforts and 36,081 through Policy, Systems, and Environmental (PSE) Changes. The TSU Supplemental Nutrition Assistant Program Education (TSU SNAP-Ed) offers evidence based, practice-tested curricula that consists of 4 to 6 multiple sessions to reinforce behavioral changes for impact during each stage of life- childhood, adolescence, adulthood, and older age. In 2019 Self-Reported Survey Data showed following impacts through TSU SNAP-Ed program: 1) Food Resource Management • Read nutrition facts labels: Adults 53.5%; Compare Prices: Adults 62.1%; • Identify foods on sale or use coupons: Adults 59.7%; • Use a grocery list: Adults 58.7%; • Not run out of food: Adults 86.2%; • Eat healthy on a budget: Adults 64.4%. 2) Healthy Eating Behaviors • Increased vegetable consumption: Adults 61.5%; Youth 47.8%. Increased fruit consumption: Adults 58.1%; Youth 52.1%. Decreased sugary drink consumption: Adults 51.2%; Youth 52.1%. • Increased low-fat milk consumption: Adults 52.9%; Youth 60.8%. Increased water consumption • Adults 95.9%; Youth 73.9% 3) Physical Activity • Increased physical activity: Adults 54.6%; Youth 73.8%	

		As a result of the UT Extension work conducted through the EFNEP and UT SNAP-Ed: TNCEP programs: 3,627 of 11,793 participants surveyed reported increased consumption of vegetables. 4,012 of 11,824 participants surveyed reported increased consumption of fruit. 715 of 2,280 participants surveyed reported improved food resource management skills. 3,937 of 11,760 participants surveyed reported increased physical activity. $45,355 in savings were reported by EFNEP program participants. The economic benefit of UT SNAP-Ed: TNCEP and EFNEP programming is $65,668,952 in reduced long-term health care costs ($42,780,876 for UT SNAP-Ed: TNCEP and $22,888,076 for EFNEP).	
20.	Consumer Food Safety	The U.S. Centers for Disease Control and Prevention (CDC) estimates that each year approximately 48 million people in the United States are sickened by a foodborne illness. In most cases, foodborne illnesses are short lived and treated at home. Other times, more vulnerable individuals including pregnant women, infants and young children, older adults, and individuals with weakened immune systems experience more serious illness leading to lifelong chronic health problems such as kidney failure, chronic arthritis, and brain and nerve damage. To make matters worse, a large number of Tennesseans already have a chronic disease that makes they more vulnerable to foodborne illness. Practicing recommended food handling behaviors such as good personal hygiene, cleaning food preparation surfaces, preventing cross-contamination, and following time and temperature controls for foods that support the growth of pathogens reduce the risk of illness. Research shows that incorporating food safety education in nutrition education, particularly when teaching food preparation, is an effective way of teaching safe food handling. Botulism is a rare but potentially deadly illness linked to improperly preserved home canned foods. Using tested recipes or processes and the right equipment prevents Clostridium botulinum bacteria from growing in home canned foods and producing a deadly neurotoxin. TSU Extension faculty member conducted in-service trainings for Extension agents and educational workshops for farmers, restaurant owners and other food handlers on the new U.S. Food Safety Modernization Act and its implications on human health.	Strengthening Our Health

		Food safety education occurs through several programs including the Expanded Food and Nutrition Education Program (EFNEP), Tennessee Nutrition and Consumer Education Program (TNCEP), Supplemental Nutritional Assistance Program education (SNAP-Ed), 4-H, Home Food Preservation programs, and culinary programs such as Fresh Plate. These groups are our identified target audience. UT and TSU Extension agents and program assistants spent 14,499 hours delivering food safety education. They made 340 contacts during client visits to the Extension office; 7,595 by direct mail, telephone and email; 19,061 through group meetings and demonstrations; and 1,549 through on-site visits such as worksite. Volunteers spent 465 hours delivering food safety education. They made 500 contacts by manning exhibits, 2,500 by writing newspaper articles, and 10,020 through social media. After participating in food safety programs, the following results were reported: • 6,265 cleaned hands and surfaces often; • 1033 did not cross-contaminate; • 1387 cooked food to a safe internal temperature; • 2095 refrigerated foods promptly within 2 hours; • 788 avoided unsafe foods such as unpasteurized milk and cheese, raw sprouts, under cooked eggs, and under cooked meat, poultry and seafood; and • 971 canned food safely following recommended practices such as following tested recipes, using a pressure canner for low acid foods, and using a boiling water canner for high acid foods. The USDA, Economic Research Service estimates that the 15 pathogens responsible for 95% of the 9.4 million episodes of foodborne illness, for which a pathogen cause can be identified, impose $15.5 billion in economic burden annually. These include associated outpatient and inpatient expenditures on medical care, and associated lost wages. The risk of infection from these 15 pathogens can be reduced by following recommended food safety practices. Using the Independent Sector's most recent value of volunteer time ($25.43), these volunteers contributed $11,824 to food safety education in Tennessee.	

21.	Healthy Diets for Chronic Disease Prevention and Management	Obesity and related chronic conditions are highly prevalent in the United States and related to disability, early death, and increased health care costs. Many of these chronic conditions are preventable and can be managed through maintaining a healthy body weight and adopting a healthy diet. Tennessee has the 12th highest adult obesity rate and the 18th, 12th, and 2nd highest obesity rates in the nation among youth aged 2-4 years participating in the Women, Infants, and Children (WIC) program, 10-17 years, and among high school students, respectively. Rates of obesity-related chronic conditions are high with Tennessee ranking the 6th highest among states for diabetes prevalence and the 7th highest among states for high blood pressure prevalence. Average intake of fruits and vegetables, a key component of healthy diets, is lower than recommendations with only 11.1% and 9.6% of Tennessee adults meeting recommendations for fruit and vegetable consumption, respectively (CDC MMWR: Disparities in State-Specific Adult Fruit and Vegetable Consumption, United States, 2015). In 2019, the University of Tennessee Extension Family and Consumer Sciences provided nutrition education programming to help Tennesseans adopt and maintain healthy diets that align with the Dietary Guidelines for Americans to prevent and/or manage obesity and related conditions. Through University of Tennessee Extension Family and Consumer Sciences nutrition programming, 278,643 adult and youth contacts were reached through direct efforts and 5,294,807 adult and youth contacts were reached through indirect methods. Programs such as Dining with Diabetes, Pathweighs to Health and Fresh Plate helped Tennesseans gain the knowledge and skills to improve their overall diets. UT Snap-Ed: TNCEP and EFNEP helped limited resource individuals and families make healthy food choices within a limited budget. UT Extension Family and Consumer Sciences helped Tennesseans plan and prepare healthy diets: • 2,810 of 4,944 (57%) of surveyed participants reported planning healthy meals. • 7,252 or 12,087 (60%) of surveyed participants reported having healthy eating patterns following the Dietary Guidelines for Americans, through dietary improvements such as eating more fruits and/or vegetables and drinking fewer sugar sweetened beverages. • 2,788 of 4,605 (61%) of surveyed participants reported preparing healthy meals.	Strengthening Our Health

		UT Extension Family and Consumer Sciences helped Tennesseans manage their food resources for healthy diets: • 1,081 of 1,531 (71%) of surveyed participants reported planning meals to manage their food resources. • 2,311 of 3,594 (64%) of surveyed participants reported utilizing food resource management strategies UT Extension Family and Consumer Sciences helped Tennesseans manage chronic conditions by planning and preparing healthy meals. The Dining with Diabetes program was delivered in six West Tennessee Counties reaching 156 individuals in 2019. Of the 156 individuals the following results were reported: • 85% of participants reported using the Healthy Plate Method to plan healthy meals. • 96% of participated reported using the Nutrition Facts Label to help them choose healthy foods. • 95% of participants reported modifying recipes to make them healthier. The potential economic benefit of University of Tennessee Extension nutrition education for chronic disease prevention and management is estimated at $53,452 through healthcare cost savings resulting from increased conformance with dietary recommendations in the Dietary Guidelines for Americans.	
22.	Developing Efficient Ways to Reduce Foodborne Illnesses	Each year in the United States, it is estimated that more than 33 million people become ill as a direct result of foodborne illness. More than 9,000 people die. The cost in lost wages, insurance claims and medical bills amounts to between $7.7 and $23 billion a year. Food safety issues are gaining increasing national attention; they have been the subject of numerous articles in the media and even as themes for TV sitcoms. Historically, pasteurization and other heat-based methods have been used to reduce the level of harmful contaminants in liquid foods. There has been a growing appreciation for the benefits of using non-heat-based treatments as a greener and more energy-efficient process to treat liquid foods. Also, some micro-organisms are getting resistant to current heat-based treatment techniques. One method is the use of ultraviolet (UV) light (highly energetic photons) to treat beverages to inactivate bacteria, viruses, and spoilage microorganisms.	Strengthening Our Health

		Research in the Food Safety and Bioprocess Engineering Program at Tennessee State University has examined new ways to increase the efficiency of ultraviolet light in reducing harmful biological and chemical contaminants in foods. The new and improved technologies developed at TSU have successfully reduced the cost of pasteurization and sterilization by 10-fold. The process is yielding increased safety and better quality of foods. A framework has been developed that will enable the process to be scaled up to an industrial/production level. Once implemented by the food processing industry, this technology will save millions of dollars per year and reduce the risk of foodborne illnesses in liquid foods.	
23.	Advancing the Detection Technologies of Salmonella in Foods	Salmonella is one of the most important foodborne pathogens. Every year, Salmonella is estimated to cause one million illnesses in the United States, with 19,000 hospitalizations and 380 deaths. To reduce the incidence of illnesses caused by Salmonella, advanced detection technology is needed to provide reliable and efficient identification of these pathogens from contaminated foods. Researchers at Tennessee State University have developed molecular fingerprint and biosensor methods for the detection of Salmonella and other foodborne pathogens in foods. The analytical methods developed in this project have shown promising results as efficient tools for food safety surveillances. The improved time-saving concentration process coupled with the automated biosensor analysis provides an attractive alternative to current methods. The researchers have collaborated with industry to further optimize the developed technologies. This research has developed a rapid and accurate detection technology to ensure food is free from contamination by pathogenic bacteria. The developed technology is intended for use by regulatory agencies, meat and poultry producers and processors to facilitate the identification of potential food safety fallouts in the processing facilities and final products. With this new technology, the testing time will be significantly reduced from days to a few hours and the cost of tests will be reduced by 50% as compared to current methods.	Strengthening Our Health

24.	Tennessee 4-H Workforce Preparation – 4-H STEM	The National Science Foundation's (NSF), "Science and Engineering Indicators 2018," concluded that most Tennessee 4th and 8th graders did not demonstrate proficiency in the knowledge and skills taught at their grade level in science and mathematics. According to NSF, 8th grade public school mathematics proficiency in 2017 in Tennessee was at 30% and 8th grade public school science proficiency in 2015 in Tennessee was at 37%. Although all of these indicators show an upward trend compared to previous NSF reports, there is still much room for improvement. Attention must be paid to introduce students to and encourage an interest in science and other Science, Technology, Engineering, and Mathematics (STEM) fields at an early age. Students oftentimes lose interest in STEM subjects by middle school (Grades 6-8) (Barker & Aspray, 2006). Early interventions help to create a STEM pipeline for students to major in STEM-related fields and enter STEM careers. Tennessee youth in grades 4-12 were targeted for this program. To encourage participation of underserved and minority youth, the majority of programs were taught in public schools. UT and TSU Extension made 519,549 direct educational contacts to help youth gain new knowledge, acquire new skills and increase aspirations regarding 4-H STEM. Tennessee youth were reached through various approaches including clubs/project groups, school enrichment, mass media, and youth from under-served and limited resource families. Seventy-eight Tennessee counties organized over 2500 4-H clubs where workforce preparation was the major emphasis. Project work was the focus and the experiential learning model was used to highlight jobs and careers aligned with 4-H projects. Activity sheets and Extension publications were developed to educate youth about practical skills related to jobs and careers. Programs were delivered through 16,183 group meetings including organized clubs, camps, project groups and school enrichment by Extension 4-H Agents and volunteers. Various school enrichment programs that focused on science, engineering and technology were conducted in 70 Tennessee counties. Youth learned about jobs and careers associated with science fields. There was a total of 850 downloads of 4-H STEM lesson plans for use in in-school and community clubs.	Developing Our Workforce

		Mass media was used to inform parents, participants and stakeholders about program opportunities and achievements. Educational programs were reinforced by 977 exhibits, 7,812 news articles, 18,291 social media posts, and 73 radio programs. For 2016-2021, TSU Extension 4-H Youth Development programs placed special emphasis on STEM programs in clubs, afterschool settings and other venues to reach youth. The ultimate goal is to increase science literacy among the state's young people. TSU Extension reached under-served and limited resource youth. As part of the Tennessee 4-H programmatic evaluation plan, youth were surveyed to determine the impact of these programs with regards to 4-H STEM. Of the youth who participated in 4-H STEM programs: • 2,490 youth can use specific scientific knowledge to form a question. • 3,164 youth can ask a question that can be answered by collecting data. • 2,491 youth can design a scientific procedure to answer a question. • 2,925 youth can record data accurately. • 2,727 youth can analyze the results of a scientific investigation. • 437 youth can communicate a scientific procedure to others. • 523 youth can use data to create a graph for presentation to others. • 458 youth can create a display to communicate scientific data and observations. • 454 youth can use science terms to share scientific results. • 426 youth can use models to explain scientific results. • 559 youth can use the results of their investigation to answer the question they had asked. • 5,099 youth report they now like science. • 3,817 youth report they are good at science. • 3,122 youth would now like to have a job related to science. • 5,011 youth now do science activities that are not for school. • 6,225 youth like to see how things are made or invented. • 7,457 youth like experimenting and testing ideas. • 7,158 youth get excited about new discoveries. • 5,327 youth report wanting to learn more about science.	

		Our outcomes for the 4-H Positive Youth Development planned program were higher than expected due to many programs being offered in public schools which reached more youth than other methods such as community clubs. Tennessee 4-H relies on the contribution of program and club volunteers. Volunteers donated 21,690.75 hours of time to 4-H STEM youth work in Tennessee.	
25.	UT Extension Afterschool Programs	One of the greatest societal changes in modern times is the increasing number of families who have both parents employed outside the home. Thus, quality after-school programming is of vital interest to parents and professionals in many communities. Not only do afterschool programs provide a safe place for children to reside, research also shows that afterschool programs provide an opportunity for students to improve academic scores and social-emotional development by providing hands-on, experiential learning activities that are an extension of the regular day classroom curricula. Since 2005, UT Extension has secured over $9 million dollars for quality afterschool programming from the Tennessee Department of Education and USDA to help schools that have received a "failing grade" as determined by the Tennessee School Report Card program. We currently operate eight afterschool programs serving 800 children. Our philosophy is to provide kids hands-on, experiential activities where they "learn by doing". The curriculum focuses on Reading, Science, Math, Technology, Health, Homework, Socialization and Leadership. The program targets children/youth who are struggling academically and emotionally. Consistently, 45% of our students below the proficient level in both math and/or reading, increase their overall grade point average in those two subjects by one full letter grade by the end of the school year. Consistently, by teacher and parent report, our students who have had office referrals on a regular basis upon entering our afterschool programs, have reduced their office referrals by over 60% while in the program. The self-esteem scales we use have shown that all "difficult" children in our programs, increase their self-perception of their own self-esteem by a significant level. Our programs focus heavily on providing children as much responsibility and leadership skills as possible. Typically, by the end of each school year, our students are the ones teaching lessons while the teachers are there more for guidance. Social	Developing Our Workforce

		and emotional (SEL) scores also increase significantly by the end of the school year in the areas of recognizing, understanding, labeling, expressing and regulating emotions. Research consistently shows that for every dollar spent on quality child care and afterschool program results in a savings of $7 due to reduced drug activity, teen pregnancy, incarceration, divorce, etc. In 2019, the UT Extension Afterschool project spent $857,228 resulting an economic savings of $5,992,000. In addition to these savings, 800 families saved an average of $300 per month not having to pay for our afterschool services. The program is used by families for 10 months out of the year. This resulted in a total savings of $2.4 million. Total economic impact for this program in 2019 is $8,392,000.	
26.	Skill Up Tennessee	Over 850,000 Tennesseans participate in the Supplemental Nutrition Assistance Program (SNAP) each month. Approximately 75% of those households have 1 or more workers, yet more than 50% have income below the poverty level. A low level of education is a barrier for many of these individuals. Knowledge of jobs available, the skills needed for those jobs, and how to gain those skills are limiting factors. Cost is an important factor as well, both for direct training costs such as tuition and books and vital supports such as transportation and childcare which often present significant barriers. Low levels of training and education affect individuals and their families as employment opportunities are limited. Middle-skill jobs, or those requiring more than a high school diploma but less than a 4-year degree, are in demand and available with a moderate amount of training. Employers are affected when there is a shortage of workers with the required knowledge, skills, and soft skills necessary to be successful in these jobs. Skill Up Tennessee is a program conducted by UT Extension's SNAP Employment and Training Program in partnership with the Tennessee Department of Labor and Workforce Development. The program was implemented to help qualifying adult SNAP participants to reach training and employment goals that lead to self-sufficiency. The program is marketed through partners at the county level, in collaboration with Family and Consumer Sciences Extension agents and Career Navigators (Extension Assistants), to recruit interested individuals for the program. The program Work Readiness Training centers on soft skills and is offered at the county level. Individual case management is provided by Career Navigators to help participants address barriers, develop a plan, and pursue training leading to employment.	Developing Our Workforce

		The focus thus far has been to establish the program at the county level, build partnerships, and develop the infrastructure to recruit and serve participants. Through small group agent trainings, agents in approximately 75 counties have been trained to participate in the program. Partnerships have been developed with statewide, regional, and local organizations to promote the program, and recruitment efforts have resulted in reaching more participants. Skill Up Tennessee has connected participants with support and resources to help them gain the training and skills needed for employment. Participation significantly increased in 2019 where 662 individuals preregistered with 556 of those verified as eligible to participate in the program. This makes up more than 30% of the state's entire SNAP Employment and Training caseload. More results reported include: • 95 participants in Work Readiness Training; • 154 participants in vocational/technical training at a Tennessee College of Applied Technology, community college, or other training provider; • 31 participants earned a recognized credential in vocational/technical training; and • 50 have obtained employment. Due to the nature of the program, these results fit the typical pattern of initial recruitment, enrollment in training that can last a year or more, then earning a credential that leads to employment. Supportive services such as tuition assistance, help with the cost of textbooks, and assistance with transportation and childcare were offered as barriers were identified. Program participants working toward a certificate or degree are set to be employed at a higher wage after graduations.	