2018 University of Tennessee and Tennessee State University Combined Research and Extension Annual Report of Accomplishments and Results

Status: Accepted

Date Accepted: 08/22/2019

I. Report Overview

1. Executive Summary

The Tennessee Agricultural Research and Extension System serves the needs of Tennesseans with research and outreach in the food, agricultural, natural resources, and human sciences. The University of Tennessee (UT) Extension and the Tennessee Agricultural Experiment Station (UT AgResearch) comprise the 1862 institution and the Tennessee State University (TSU) Cooperative Extension Program and the TSU Institute for Agricultural Research comprise the 1890 institution. This report represents the combined efforts of UT Extension, UT AgResearch, TSU Cooperative Extension Program, and the TSU Institute for Agricultural Research.

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 2018, 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. Using research, questionnaires, observations and sales records, an estimated impact was more than $620 million for FY 2018. It was estimated that for every $1 in public funds invested in Extension, $10.26 was returned to the people of Tennessee in increased revenue, increased savings and one time capital purchases.

The recurring economic impacts were estimated at over $378 million. These recurring economic values include increased revenue, increased savings and one time capital purchases associated with Extension programs in crop variety trials/pest control, forage systems, 4-H camping, pesticide safety education, integrated pest management, turfgrass weed management, apiculture, and optimizing beef production. Using a UT System standard formula, an estimated 7,578 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 $241 million from Extension programs in nutrition education, health literacy, residential horticulture, Tennessee Saves, and volunteerism.

Extension's Excellence in Outreach: UT and TSU Extension professionals and the volunteers they recruited, trained, and managed made more than 4.2 million direct contacts through group meetings, onsite visits (farm, home, and workplace), phone calls, direct mail, and client visits to local Extension offices. 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 12 years, (2006-2018), this reporting system has been demonstrated to the administrators of 25 state Extension organizations who regarded it as a national model for Extension accountability.

Excellence in Agricultural Research: The cornerstone of agricultural research emphasis at Tennessee State University continues to be the high-priority areas identified by NIFA. Research focus groups are maintained around these priority areas and all research is conducted under the review of a focus group. To address the increasing need for trained agriculture graduates in the US, the College of Agriculture at TSU continues to expand, in both human and physical resources. This past year we added

expertise in the area of sustainable bioenergy and a major facility expansion in the area of food safety is in the final design phase.
The goal of agriculture research at TSU remains the same: to create and communicate new knowledge in the agricultural and environmental sciences for the prosperity of the citizens of Tennessee, the nation and the world. Our faculty and staff have been educated and trained at many of the best institutions in the US and the world and continue to dedicate themselves to improving the lives of others. This group of individuals takes pride in partnering with NIFA to advance agricultural and environmental research at Tennessee State University to make a positive difference in our society. We believe the research described in this report illustrates our commitment to serving our stakeholders and improving the lives of the world's citizens. Examples of research accomplishments include:

- Innovative techniques for vegetable production for urban dwellers
- New methods to control regulatory insects using bee-friendly techniques
- New soybean gemplasm for decreased unhealthy trans-fats
- Utilizing alternative crops, such as Pigeon pea, in healthy food applications for antioxidant, anti-diabetic, and anti-inflammatory uses
- Development of improved alternative weed management practices as a result of methods to rapidly identify glyphosate-resistant weeds
- Innovative research to improve biofuel crops through mircospore molecular marker development
- Identification of new methods to reduce toxins that are resistant to normal pasteurization techniques in milk
- Development of environmentally friendly microorganisms to control diseases in food crops

UT AgResearch conducts basic and applied research in agricultural and natural resource areas within its seven academic departments, seven physical centers (in addition to several virtual ones), and at ten AgResearch and Education Centers located throughout the state. These units help drive planned research in identified critical areas and facilitate the faculty's research projects. In 2018, several noteworthy outcomes resulted from research projects across planned programs. Researchers developed a genotyping tool to detect Bt resistance alleles in insects to combat growing resistance to Bt corn. Studies of a Staphylococcus chromogenes (SCSP) vaccine showed it has promising potential to control mastitis in dairy cows. Research revealing the impacts of climate variation and climate change on onsite wastewater treatment systems provides engineers with data necessary to ensure that groundwater is protected. Researchers developed a novel tool for chloroplast biotechnology. Site surveys revealed the presence of the Lyme disease vector - the blacklegged tick - for the first time in multiple Tennessee counties, informing public health officials and veterinarians of a potential rise in Lyme disease in those areas. After two decades of effort, researchers saw the natural restoration of native fauna to the Pigeon River. Efforts to help the nursery industry improve water management and reduce runoff resulted in irrigation practices that reduced water use.

Total Actual Amount of professional FTEs/SYs for this State

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	450.0	90.0	330.0	74.0
Actual	450.0	101.0	223.0	78.0

II. Merit Review Process

1. The Merit Review Process that was Employed for this year

- Internal University Panel
- External University Panel
- Expert Peer Review

2. Brief Explanation

The merit review and peer review processes established in the latest Plan of Work were implemented nine 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 2018.
Each TSU planned outcome in this Annual Report has been peer-vetted by members of an internal topic-related focus group and by the college administration. Some programs had the benefit of an additional review by an external panel. These panels are composed of agricultural researchers and administrators in the 1890 University system. Faculty proposals within the Planned Programs are evaluated for relevance, scientific soundness, and appropriateness of planned outcomes. Only those proposed programs that successfully meet all criteria are developed into executable outcome objectives.
The TSU College of Agriculture has continued to hold an annual retreat for faculty. This two day, off-campus event provides an opportunity for focus group members to dedicate time to discuss, evaluate, and plan program objectives without the distractions of campus life. In addition, the Associate Deans of the college continue to have individual meetings with faculty members regularly. These meetings facilitate an almost continuous avenue for monitoring of progress and problem resolution. These procedures contribute significantly to ensure that the Planned Programs are executed efficiently and with maximum benefit to stakeholders.
UT AgResearch Hatch regular and Hatch/Multi-state research projects included in this report each underwent a project proposal review process for merit and scientific soundness, and to ensure that they aligned with established research priorities. Prior to writing a new Hatch project or joining a Hatch/Multi-state project, the faculty have informal discussions with collaborators, their department head, and if applicable, AgResearch and Education Center administrators where any work may take place. Hatch regular projects undergo a two-level review process prior to submission to NIFA. Because Hatch/Multi-state projects go through a comparatively more complex review at the regional level, the internal review process is abbreviated to just one level. Once fully approved, any project that takes place at one of our AgResearch and Education Centers requires a formal workplan detailing how the project gets done on the ground. Our online workplan submission and approval process allows rapid interactive review and revision of workplans among the faculty, department heads, AgResearch and Education Center administrators, Deans, and compliance officers. With a central document repository, all those involved can be "on the same page," no matter where they are located.

III. Stakeholder Input

1. Actions taken to seek stakeholder input that encouraged their participation

- Targeted invitation to traditional stakeholder groups
- Targeted invitation to traditional stakeholder individuals
- Targeted invitation to non-traditional stakeholder individuals
- Targeted invitation to selected individuals from general public
- Survey of traditional stakeholder groups
- Survey of traditional stakeholder individuals

- Survey specifically with non-traditional groups
- Survey of selected individuals from the general public
- Other (Local and State Advisory Councils)

Brief explanation.

In FY 2018, UT and TSU Extension made 6080 contacts for needs assessment purposes, with these methods highlighted:

- 73 advisory committee meetings
- 74 open listening sessions
- 140 focus groups
- 1264 surveys

Tennessee Extension Agents placed special emphasis on involving youth and other underrepresented groups in needs assessment activities. Both TSU and UT Extension administrators meet with the State Extension Advisory Council at least twice a year to help determine the needs and direct educational programs. Input from non-traditional stakeholder individuals is seen as particularly valuable to the institutions. At the county level, extension agents meet with local advisory councils and various stakeholders to determine programming needs.
The TSU college of Agriculture places a very strong emphasis on our faculty to be members of, and adopt service/leadership roles in, the industry/trade/commodity/professional organizations associated with their research. Through the development of relationships with the leadership and members of stakeholder-related organizations, valuable stakeholder input is gained and incorporated into our programs.

Examples of associations in which our faculty have enhanced roles of engagement are the: Southern Nursery Association, Tennessee Soybean Board, Tennessee Cattlemen's Association, Amaranth Institute, Tennessee Organic Growers Association, Tennessee Nursery and Landscape Association, SE Branch - Entomological Society of America, International Plant Propagator's Society, Tennessee Goat Producers Association, and the Tennessee Urban Forestry Council.

In addition to private groups, our faculty regularly engage public agencies to provide guidance and feedback about our programs. Agencies include the Tennessee Department of Agriculture, Tennessee Department of Forestry, Tennessee Plant Material Advisory Committee, Tennessee Wildlife Resources Agency, Tennessee Department of Environment and Conservation, USDA APHIS, USDA ARS, USDA FSA, USDA FS, USDA NRCS, USDA RD and USDA RMA. Additionally, a number of different programs maintain an active presence on social media (Facebook, Twitter) and utilize feedback gained from those sources.
UT AgResearch sought stakeholder feedback at multiple levels. We continued our successful partnerships with commodity and industry groups, the Tennessee Farm Bureau, and several departments within the state government to advance common research interests.
Advocacy/advisory groups served each of the seven UT AgResearch academic departments and the ten AgResearch and Education Centers to provide stakeholder feedback and to guide future research priorities. At an individual level, faculty helped drive the UT AgResearch agenda by remaining abreast of emerging research and actively engaging with the scientific community, program leaders with state and federal funding agencies, the general public, and agricultural and natural resources commodity and industry groups.

2(A). A brief statement of the process that was used by the recipient institution to identify individuals and groups stakeholders and to collect input from them

1. Method to identify individuals and groups

- Use Advisory Committees
- Use Internal Focus Groups
- Open Listening Sessions
- Needs Assessments
- Use Surveys
- Other (See below.)

Brief explanation.

All Tennessee Extension (UT and TSU Extension) Agents receive instruction in selecting needs assessment strategies and in selecting individuals for Advisory Committees. Community leaders selected from Advisory Committees are chosen to represent the diversities (i.e., gender, age, racial/ethnic, socio-economic, political, educational, etc.) of the county or area served. Extension Agents recruit individuals who have participated in past and current Extension programs; and they recruit individuals who have not used Extension to serve on local advisory committees and participate in open listening sessions. Surveys are also given to traditional and non-traditional stakeholders as well.
The College of Agriculture at TSU research does not employ a single defined strategy to identify stakeholders, rather our goal is to identify stakeholders in a manner that will provide the most useful and accurate feedback possible about stakeholder concerns. Groups that serve the stakeholders (community based groups) or groups that represent stakeholders (industry and trade associations) are a primary source of input. Examples of groups are listed in the previous section, Actions to Seek Stakeholder Input. Individual stakeholders are utilized where there are no associated groups representing the program area, or when an opportunity for face-to-face interaction (i.e. at an association meeting, field site visit, or community event) is presented. In these cases, individuals involved the program outputs are identified and queried for input.
UT AgResearch administrators and faculty are actively engaged with agricultural and natural resources commodity and industry groups. As new priorities arise, these groups seek out one another to discuss common research priorities and opportunities for partnership. Advocacy/advisory groups for the UT AgResearch academic departments and the AgResearch and Education Centers identify additional stakeholders based on the individuals' and groups' relevant background, expertise, and community connections, etc. UT AgResearch faculty regularly interact with their peers at professional meetings and through joint project ventures. UT AgResearch administrators encourage faculty to meet with program leaders at state and national funding agencies to discuss research priorities. Faculty have opportunities to meet with the public during AgResearch and Education Center field day events.

2(B). A brief statement of the process that was used by the recipient institution to identify individuals and groups who are stakeholders and to collect input from them

1. Methods for collecting Stakeholder Input

- Meeting with traditional Stakeholder groups
- Survey of traditional Stakeholder groups
- Meeting with traditional Stakeholder individuals
- Meeting with the general public (open meeting advertised to all)

- Survey specifically with non-traditional individuals

Brief explanation.

The System for University Planning, Evaluation and Reporting (SUPER) tracks Extension's needs assessment efforts across Tennessee. In FY 2018, Extension conducted 140 different focus groups and 2779 interviews with key informants.
As has been the case in previous years, most stakeholder input for the TSU College of Agriculture research is collected in either face-to-face discussions, interaction with commodity groups, or via survey instruments. Each of these methods are effective. The face-to- face discussions are often held with individual stakeholders, community group representatives or trade association representatives, or with individual stakeholders in a group setting. This allows for questions and answers to direct and stimulate discussion of areas of importance to stakeholders. Survey instruments are a useful tool to assess information from broader groups of stakeholders. Our nursery research programs regularly employ surveys of producers to solicit feedback on important issues; surveys for feedback on individual topics are also used following informational talks at educational programs, field days, etc. While some stakeholders prefer the anonymity and brevity of a survey instrument (often resulting in increased level of input gained), a survey instrument does not always allow for discussion of previously unrecognized areas of concern. The increased acceptance of social media has also presented opportunities for stakeholder input. A number of our programs maintain an active presence on social media and these platforms serve as a source of information on stakeholder needs and concerns. All research presentations to non-academic stakeholders now solicit feedback via evaluations. The information gained from these surveys is incorporated into program focus areas.
UT AgResearch collects information from stakeholders in various ways. AgResearch administrators meet with external stakeholders throughout the year. They have face-to-face meetings with the academic department heads and virtual meetings with the AgResearch and Education Center directors every month. Collectively, these three groups meet annually. The UT AgResearch academic departments and AgResearch and Education Centers meet with their advocacy/advisory groups annually, and share stakeholder feedback with AgResearch administrators and faculty as appropriate. Faculty attend professional meetings and read scientific journals and popular press articles throughout the year. Departments hold monthly faculty meetings where individuals have the opportunity to share their insights with peers and their department head. Many of our UT AgResearch faculty are active on social media and radio, in local producer and hobbyist clubs, and in popular farm and garden publications, providing additional exposure to a wide variety of individuals and groups.

3. A statement of how the input will be considered

- In the Budget Process
- To Identify Emerging Issues
- Redirect Extension Programs
- Redirect Research Programs
- In the Staff Hiring Process
- In the Action Plans
- To Set Priorities

Brief explanation.

The State Action Agendas (state plans of work) delineated programs, curricula, partners and resources for addressing stakeholder concerns. Individual plans were created and implemented by

Extension Agents and Specialists based on the results of the needs assessments. The plans were reviewed, adjusted and monitored by Regional Program Leaders and Department Heads. In FY 2018, stakeholder input was used to identify volunteer leaders, identify new audiences, and identify and secure locations for Extension programs. Examples of how stakeholder input informed programs and resources include:

- Specialists and faculty developed 95 Extension bulletins for all 95 Tennessee counties related to the County Level Economic Impact of Agriculture as a resource to help farmers, Extension agents, and other stakeholders to advocate for the economic benefits of agriculture in their communities
- In west Tennessee, over 90% of soybean and cotton production are dryland. Producers have few options to mitigate drought stress. A program was developed to introduce high water saving potential lines. Field days, in-services, news articles, and publications were used to promote the adoption of high water saving lines on dryland acres.
- Obesity prevention and chronic disease management continue to be top concerns for Tennessee residents. Tennessee Extension strengthened health programming by offering the CDC Diabetes Prevention Program--a program that has demonstrated effectiveness in preventing adults with prediabetes from developing diabetes. This intensive program was piloted in two Tennessee counties and will be expanded in FY 2019.

As previously stated, program activities in the TSU College of Agriculture utilize stakeholder input during the planning and execution of programs. Information gained through this process did not result in any overt changes in research direction or scope this past year. Rather, it provided information on additional facets for research exploration. For example, in discussions with nursery growers about alternatives to the potentially banned insecticide chlorpyrifos, plans to include dip treatments were removed from consideration upon emphatic feedback from stakeholders on the impracticality of such treatments. These sorts of input are the types of stakeholder-inspired modifications we encounter most frequently.

For UT AgResearch, stakeholder input is an active part of setting research and budget priorities, and redirecting allocations as critical needs emerge, are addressed, and wane. Stakeholder input directly impacts hiring patterns, faculty equipment budgets, publicity efforts, and forward-looking action plans. The publication and grant proposal feedback loops impact our priorities as well. The acceptance for publication or grant funding, reviewer comments, and the ultimate traction of a particular publication (in citations) or funded project provide an impetus, particularly for pre-tenure faculty, to work on research that is timely and compelling.

Brief Explanation of what you learned from your Stakeholders

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counties and will be expanded in FY 2019.

IV. Expenditure Summary

1. Total Actual Formula dollars Allocated (prepopulated from C-REEMS)			
Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
{No Data Entered}	{No Data Entered}	{No Data Entered}	{No Data Entered}

2. Totaled Actual dollars from Planned Programs Inputs				
	Extension		Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	8952851	2938031	6029717	2344865
Actual Matching	43995126	4430512	6512899	3328439
Actual All Other	11541214	934211	0	0
Total Actual Expended	64489191	8302754	12542616	5673304

3. Amount of Above Actual Formula Dollars Expended which comes from Carryover funds from previous				
Carryover	0	0	0	0

V. Planned Program Table of Content

V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

4-H Positive Youth Development

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
803	Sociological and Technological Change Affecting Individuals, Families, and Communities	25%	25%	0%	0%
806	Youth Development	75%	75%	0%	0%
	Total	100%	100%	0%	0%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	158.0	17.0	0.0	0.0
Actual Paid	153.0	45.0	0.0	0.0
Actual Volunteer	37.5	85.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
3043969	1303884	0	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
14958343	1970720	0	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
768282	414123	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

• **Clubs/Project Groups -** 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.

• **School Enrichment -** 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.

• **Mass media** - Mass media was used to inform parents, participants and stakeholders about program opportunities and achievements.

• **Youth from Under-Served and Limited Resource Families:** 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.

2. Brief description of the target audience

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.

3. How was eXtension used?

In 2018, 4-H Specialists and agents were members of eXtension Community of Practice for Military Families, the 4-H Learning Network, and 4-H Computer Science Community. Members answered questions related to 4-H topics.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	567622	0	1800240	19816371

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	44	0	44

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of volunteers utilized in delivering this program.

Year	Actual
2018	2055

Output #2

Output Measure

- Number of exhibits produced.

Year	Actual
2018	1849

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Achieving Goals: Number of youth who now put their goal in writing.
2	Achieving Goals: Number of youth who now report they set high goals.
3	Achieving Goals: Number of high school youth who have set a goal for their job or career.
4	Communicating: Number of youth who can express ideas with a poster, exhibit, or other display.
5	Communicating: Number of youth who can use technology to help themselves express ideas.
6	Communicating: Number of youth who have learned at least five jobs in which communication skills are important.
7	Communicating (Public Speaking): Number of youth who can deal with their nervousness when giving a speech or talk.
8	Communicating (Public Speaking): Number of youth who can select a topic for a speech or talk.
9	Communicating (Public Speaking): Number of youth who can speak loudly enough to be heard when giving a speech or talk.
10	Communicating (Public Speaking): Number of youth who feel comfortable sharing their thoughts and feelings in a speech or talk.
11	SET: Number of youth who can design a scientific procedure to answer a question.

Outcome #1

1. Outcome Measures

Achieving Goals: Number of youth who now put their goal in writing.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	6246

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
806	Youth Development

Outcome #2

1. Outcome Measures

Achieving Goals: Number of youth who now report they set high goals.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	5291

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
806	Youth Development

Outcome #3

1. Outcome Measures

Achieving Goals: Number of high school youth who have set a goal for their job or career.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	2451

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
806	Youth Development

Outcome #4

1. Outcome Measures

Communicating: Number of youth who can express ideas with a poster, exhibit, or other display.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	7571

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
806	Youth Development

Outcome #5

1. Outcome Measures

Communicating: Number of youth who can use technology to help themselves express ideas.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	7070

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
806	Youth Development

Outcome #6

1. Outcome Measures

Communicating: Number of youth who have learned at least five jobs in which communication skills are important.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	6756

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
806	Youth Development

Outcome #7

1. Outcome Measures

Communicating (Public Speaking): Number of youth who can deal with their nervousness when giving a speech or talk.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	16210

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
806	Youth Development

Outcome #8

1. Outcome Measures

Communicating (Public Speaking): Number of youth who can select a topic for a speech or talk.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	18507

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
806	Youth Development

Outcome #9

1. Outcome Measures

Communicating (Public Speaking): Number of youth who can speak loudly enough to be heard when giving a speech or talk.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	16184

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
806	Youth Development

Outcome #10

1. Outcome Measures

Communicating (Public Speaking): Number of youth who feel comfortable sharing their thoughts and feelings in a speech or talk.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	14715

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
806	Youth Development

Outcome #11

1. Outcome Measures

SET: Number of youth who can design a scientific procedure to answer a question.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	3189

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
803	Sociological and Technological Change Affecting Individuals, Families, and Communities
806	Youth Development

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Other (Program Delivery in Public Schools)

Brief Explanation

Our outcomes for the 4-H Positive Youth Development planned programs were higher than expected due to many programs being offered in public schools which reached more youth compared to other methods such as community clubs.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The National Science Foundation's (NSF) "Science and Engineering Indicators 2016" 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. Therefore, Extension 4-H programs emphasized science, technology, engineering and mathematics to bolster science literacy and inform youth about career pathways. In FY 2018, we evaluated 4-H STEM programming with surveys. Our evaluation results showed that Tennessee 4-H programs improved science literacy with the following results:

- 3,305 youth can use specific scientific knowledge to form a question
- 4,487 youth can ask a question that can be answered by collecting data
- 3,189 youth can design a scientific procedure to answer a question
- 3,866 youth can record data accurately
- 7,399 youth get excited about new discoveries
- 7,665 youth like experimenting and testing data

Key Items of Evaluation

4-H STEM programming in Tennessee complements school science programs through hands-on, interactive science experiences that reinforce STEM learning and careers. Outcomes included:

- 3,305 youth can use specific scientific knowledge to form a question
- 4,487 youth can ask a question that can be answered by collecting data
- 3,189 youth can design a scientific procedure to answer a question
- 3,866 youth can record data accurately
- 7,399 youth get excited about new discoveries
- 7,665 youth like experimenting and testing data

V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

Agronomic Crop Systems

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
101	Appraisal of Soil Resources	0%	0%	2%	0%
102	Soil, Plant, Water, Nutrient Relationships	0%	0%	21%	0%
104	Protect Soil from Harmful Effects of Natural Elements	0%	0%	3%	0%
111	Conservation and Efficient Use of Water	0%	0%	1%	0%
133	Pollution Prevention and Mitigation	0%	0%	1%	0%
201	Plant Genome, Genetics, and Genetic Mechanisms	0%	0%	13%	20%
202	Plant Genetic Resources	0%	0%	6%	26%
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants	0%	0%	1%	7%
204	Plant Product Quality and Utility (Preharvest)	0%	0%	1%	20%
205	Plant Management Systems	50%	50%	9%	20%
211	Insects, Mites, and Other Arthropods Affecting Plants	5%	5%	6%	0%
212	Pathogens and Nematodes Affecting Plants	5%	5%	8%	7%
213	Weeds Affecting Plants	0%	0%	7%	0%
312	External Parasites and Pests of Animals	0%	0%	5%	0%
402	Engineering Systems and Equipment	0%	0%	9%	0%
404	Instrumentation and Control Systems	0%	0%	4%	0%
502	New and Improved Food Products	0%	0%	1%	0%
601	Economics of Agricultural Production and Farm Management	40%	40%	0%	0%
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins	0%	0%	2%	0%
	Total	100%	100%	100%	100%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	4.0	1.0	70.0	13.0
Actual Paid	45.0	5.6	18.0	11.5
Actual Volunteer	0.4	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
895285	163842	996227	345717
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
4399513	246829	1071075	490731
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
1198314	52098	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

The Extension portion of this plan includes cotton, irrigation, entomology, plant pathology and row crops management and marketing issues. Based on needs assessments conducted by Extension Specialists, the following practices were targeted: conservation-tillage; planting insect-tolerant crops; planting herbicide-tolerant crops; spaying crops with foliar fungicide to manage disease; using recommended varieties (based on UT field trial results).

Newspaper articles, radio programs, websites and newsletters were used to build awareness of UT Extension resources and practices for more profitable production. Mass media also highlighted pests and pesticides based on time of year so producers would have the information in time to adapt practices to make the most impact. Farm visits and group meetings were used to showcase practices. Extension specialists delivered detailed instruction to producers through group meetings and classes. On-farm demonstrations were conducted throughout the state with a particular emphasis in 31 counties located in the western part of the state to highlight research-based practices. To the extent possible, integrated research and extension was conducted such as result demonstrations and test plots in all 31 west Tennessee counties. Follow-up farm visits and telephone calls were conducted to assist producers to continue use of the practices, respond to environmental factors, and realize greater profits.

The research portion of this program focuses on improved disease and insect resistance mechanisms in crops, development of new varieties, increased yields, discovery of new markets, improved production practices, and reduced production inputs.

2. Brief description of the target audience

The primary audience for this program is Tennessee row crop producers, and the secondary audience is the professionals, business owners/cooperatives, and government officials who serve row crop producers.

3. How was eXtension used?

Tennessee Extension personnel were part of the eXtension "Plant Breeding and Genomics" and "Corn and Soybean Producers" Community of Practice. Members answered questions related to farm management practices..

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	63348	11964727	2846	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	113	53	166

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of exhibits displayed to promote awareness and participation in this planned program.

Year	Actual
2018	7

Output #2

Output Measure

- Number of research-based publications distributed as part of this program.

Year	Actual
2018	94655

Output #3

Output Measure

- Research Fertilizer Efficiency Enhancers (Yin)
  Not reporting on this Output for this Annual Report

Output #4

Output Measure

- Fight Fungal Pathogens of Snapbean and Soybean (Canaday)
  Not reporting on this Output for this Annual Report

Output #5

Output Measure

- Develop New Cereal Varieties (West)

Year	Actual
2018	96000

Output #6

Output Measure

- Engineer Drought-Tolerant Bioenergy Crops (Cheng)
  Not reporting on this Output for this Annual Report

Output #7

Output Measure

- Enhance Bioactive Food Components (Kopsell, Armel, Sams, Deyton)
  Not reporting on this Output for this Annual Report

Output #8

Output Measure

- Genetically Improve Soybean Yields (Pantalone)
  Not reporting on this Output for this Annual Report

Output #9

Output Measure

- Address Genetic Resistance to Bt Toxins (Jurat-Fuentes)
  Not reporting on this Output for this Annual Report

Output #10

Output Measure

- Use Remote Sensing for Variable-rate Nitrogen Application (Gwathmey, Yin)
  Not reporting on this Output for this Annual Report

Output #11

Output Measure

- Understand Soybean Mosaic Virus Virulence (Hajimorad)
  Not reporting on this Output for this Annual Report

Output #12

Output Measure

- Evaluate New Crop Varieties (Allen)
  Not reporting on this Output for this Annual Report

Output #13

Output Measure

- Fact Sheet of recommendations to farmers/producers to grow/manage pigeon pea in Tennessee and surrounding states. (Duseja)
  Not reporting on this Output for this Annual Report

Output #14

Output Measure

- Investigate Appropriate Use of Unmanned Aircraft Systems (Freeland)
  Not reporting on this Output for this Annual Report

Output #15

Output Measure

- Evaluate a Foldable Tractor RollOver Protection System (Ayers)
  Not reporting on this Output for this Annual Report

Output #16

Output Measure

- Evaluate Spent Microbial Biomass for Amending Corn and Fescue (Eash)
  Not reporting on this Output for this Annual Report

Output #17

Output Measure

- Release High Oleic Soybean to Eliminate Hydrogenation (Pantalone)
  Not reporting on this Output for this Annual Report

Output #18

Output Measure

- Conduct cotton and wheat field trials to assess various production practices (Raper)

Year	Actual
2018	100

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Row Crops Production: Number of participants who implemented one or more management practices based on data provided by UT (e.g., conservation tillage, plant population, growth retardants, IPM strategies, disease and weed control).
2	Row Crops Production: Number of producers, farm workers and other ag professionals who received pesticide certification, recertification and pesticide safety training.
3	Row Crops Production: Number of participants who improved their income by following the recommended best management practices for crop production, including plant pest management.
4	Soybeans: Number of producers who learned soybean best management practices that can improve production potential (e.g., conservation tillage, winter covers, plant population, row spacing, planting dates, plant growth regulators, harvest, variety selection, irrigation, fertility).
5	Create Genetic Mapping Populations of Soybean (Pantalone)
6	Investigate Insect Resistance to Biopesticides (Jurat-Fuentes)
7	Identify Molecular and Genomic Plant Defense Mechanisms (Chen, Grant)
8	Explore Nematode and Arthropod Biodiversity (Bernard)
9	Attack the Soybean cyst Nematode (Hewezi, Hajimorad)
10	Precision protocols will be developed for nucleic acid extraction from isolated cotton pollen and microspores towards molecular marker based analyses of cotton lines. (Aziz)
11	Agricultural and Environmental Sciences research knowledge will be enhanced for undergraduate and/or graduate students through laboratory experiential learning. (Aziz)
12	Improve amaranth as an alternative crop and increase profitability of farming in small acreages through the production of alternative crops. (Blair)
13	Increase soybean genetic diversity. (Taheri)
14	Identify vegetable cultivars suitable for organic management system and to improve efficiency of organic farming by proper allocation of inputs. (Nandwani)
15	Research to better understand the bacterial wilt disease process and the role of individual genes in the disease process. (Dumenyo)
16	Define the natural enemy complex for the Brown Marmorated Stink Bug (Moore)
17	Engineer drought-tolerant bioenergy crops (Cheng)

18	Biofuel crop enhancement through mircospore molecular marker development. (Aziz)
19	Producers in urban settings will adopt new technology/strategies developed for vegetable production as a part of an urban agriculture project. (Nandwani)
20	Organic growers in Tennessee will adopt new technology/strategies developed for the vegetable production. (Nandwani)
21	Extension Corn Production Programs Increase Total Farm Income
22	Extension Soybean Production Programs Increase Total Farm Income
23	Extension Wheat Production Programs Increase Total Farm Income
24	Tennessee Extension Leads Variety Test Program for Corn Grain, Silage, and Soybeans
25	Increased understanding of the role of cover crops in improving nitrogen levels in soil (Jagadamma)
26	Identification of potential applications of unmanned/uncrewed airborne systems (UAS) in precision agriculture (Freeland)
27	Develop a genotyping tool to detect Bt resistance alleles in insects (Jurat-Fuentes)

Outcome #1

1. Outcome Measures

Row Crops Production: Number of participants who implemented one or more management practices based on data provided by UT (e.g., conservation tillage, plant population, growth retardants, IPM strategies, disease and weed control).

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	2408

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems

Outcome #2

1. Outcome Measures

Row Crops Production: Number of producers, farm workers and other ag professionals who received pesticide certification, recertification and pesticide safety training.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	5312

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
211	Insects, Mites, and Other Arthropods Affecting Plants

Outcome #3

1. Outcome Measures

Row Crops Production: Number of participants who improved their income by following the recommended best management practices for crop production, including plant pest management.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	2408

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
601	Economics of Agricultural Production and Farm Management

Outcome #4

1. Outcome Measures

Soybeans: Number of producers who learned soybean best management practices that can improve production potential (e.g., conservation tillage, winter covers, plant population, row spacing, planting dates, plant growth regulators, harvest, variety selection, irrigation, fertility).

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	951

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
211	Insects, Mites, and Other Arthropods Affecting Plants
213	Weeds Affecting Plants

Outcome #5

1. Outcome Measures

Create Genetic Mapping Populations of Soybean (Pantalone)

Not Reporting on this Outcome Measure

Outcome #6

1. Outcome Measures

Investigate Insect Resistance to Biopesticides (Jurat-Fuentes)

Not Reporting on this Outcome Measure

Outcome #7

1. **Outcome Measures**

   Identify Molecular and Genomic Plant Defense Mechanisms (Chen, Grant)

   Not Reporting on this Outcome Measure

Outcome #8

1. **Outcome Measures**

   Explore Nematode and Arthropod Biodiversity (Bernard)

   Not Reporting on this Outcome Measure

Outcome #9

1. **Outcome Measures**

   Attack the Soybean cyst Nematode (Hewezi, Hajimorad)

   Not Reporting on this Outcome Measure

Outcome #10

1. **Outcome Measures**

   Precision protocols will be developed for nucleic acid extraction from isolated cotton pollen and microspores towards molecular marker based analyses of cotton lines. (Aziz)

   Not Reporting on this Outcome Measure

Outcome #11

1. **Outcome Measures**

   Agricultural and Environmental Sciences research knowledge will be enhanced for undergraduate and/or graduate students through laboratory experiential learning. (Aziz)

2. **Associated Institution Types**

   - 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
A NIFA priority area includes enhancing student recruitment and retention. The TSU agricultural sciences program strives to increase the educational opportunities for target populations. The identified needs for students include heightening interest in science, engineering, and technology (SET), as well as research through unique approaches while routing students into degree programs aimed towards natural resources preservation and enhancement through SET education.

What has been done
This project supported undergraduate and graduate educational endeavors by providing laboratory-based training as per student level of knowledge. Students were prepared through hands-on higher educational training opportunities. Two undergraduate students and two graduate students have been involved during greenhouse and laboratory-based procedures for this research project. Thus, through sweet sorghum plant maintenance, data analyses and molecular protocols (individual microspore isolation, molecular marker procedures, nucleic acid extraction from microspores), student training for both undergraduate and graduate levels were provided.

Results
The procedures developed and research results produced have been effectively disseminated to communities of interest. Both undergraduate students have either graduated or about to be graduated from Tennessee State University with a B.S. degree in Agricultural Science with biotechnology concentration.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms

Outcome #12

1. Outcome Measures

Improve amaranth as an alternative crop and increase profitability of farming in small acreages through the production of alternative crops. (Blair)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Alternative crops are needed by Tennessee farmers who rely on a small gamut of possible crops (corn, soybean, forage and cotton) on most acreage in the state. One attractive new crop is the Grain Amaranth, a C4 plant like maize but which is from the broadleaf family of plants (dicotyledons) and which is harvested for small seed and forage potential. Grain amaranths do not cross with most weed species such as Palmer or Spiny Amaranths in the state of Tennessee or in the midwest. Grain amaranth cultivars can be used to compete with weeds and reduce their populations as they have larger leaves, taller plants and greater competitiveness than weeds.

What has been done
Apart from molecular work described in last year's report (KASP markers) this year concentrated on field work. Direct seeding into a lightly tilled field dragged over with a corn planter for row making was developed as a planting technique for Grain Amaranth. Grain Amaranth adaptation to low soil fertility was measured by keeping fertilization completely organic and not adding fertilizers other than crop residues from a previous season. In addition, no pesticides were used to identify if the new varieties were susceptible to any diseases. A new harvesting technique was employed in which heads were snapped, dried in a hoop-house and threshed with a thresher/blower.

Results
In total, we multiplied the top 6 genotypes from US Department of Agriculture (USDA) and Seed Savers Exchange (SSE) germplasm. These grain amaranth varieties are now available for growing conditions in Tennessee. Among the varieties we employed this year, two were identified as high yielding and disease resistant, despite low fertility and a hot summer season. They were also drought tolerant as one month went by before flowering with no rainfall events.

4. Associated Knowledge Areas

KA Code	Knowledge Area
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants

Outcome #13

1. Outcome Measures

Increase soybean genetic diversity. (Taheri)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	9

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Generating new soybean germplasm is necessary for addressing increasing demands for food and feed and adding beneficial traits to the crop. It is also necessary to improve nutritional values in soybeans. Soybean oil has high amounts of saturated fatty acids which are reported to increase cardiovascular diseases. Through mutation, it is possible to change soybean oil content and make it similar to olive oil which is rich in heart healthy fatty acids. Herbicide resistance, reduced allergens and lower phytic acid are other important traits which are in high demand by farmers and consumers.

What has been done
More than 10,000 soybean seeds have been treated with EMS for generating random mutations in the soybean genome. About 2000 M1 plants survived the treatment and grew to full maturity. Seeds were harvested from these plants and about 12 seeds were planted from each M1 plant for phenotypic evaluation and DNA extraction. More than 20,000 soybean seeds from the 2000 M1 mutants were planted, of which 6,500 of these plants survived to maturity. Individual plants were harvested manually and threshed at the end of growing season. Plant yield and seed compositions such as total oil and protein contents, fatty acid and amino acid profiles were measured from each single mutants. The data generated from this germplasm enhancement will be used in fishing out mutations in genes involved in beneficial traits. We extracted DNA from all these individual plants for further analysis and screening for herbicide resistance germplasm.

Results
More than 50 mutants were recovered that have higher yield compared to the control plants. These results was also validated using a field trial with replicates and proper experimental design. We discovered 9 mutants with more than 39% oleic acid content (heat healthy oil) which is considerably higher than 25.4% in parental line. Mutants were also discovered with less than 3% saturated fats (Linolenic acid) which is less than the parental line (7.6%). Mutants with other

phenotypic changes were also observed and recorded in this population.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources

Outcome #14

1. Outcome Measures

Identify vegetable cultivars suitable for organic management system and to improve efficiency of organic farming by proper allocation of inputs. (Nandwani)

Not Reporting on this Outcome Measure

Outcome #15

1. Outcome Measures

Research to better understand the bacterial wilt disease process and the role of individual genes in the disease process. (Dumenyo)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Vegetables make up a very important component of human diet. Vegetables are also susceptible to a devastating 'equal opportunity' disease called bacterial soft rot that infects over 80 different plant species both in the field and storage. Although the causal bacterium is related to the well-studied human pathogen, E. coli, there is still a lot that we do not know about soft rot bacteria. The disease, sanitation, cultural practices and host resistance remain the only approaches for managing soft rot. Pathogen-based management of bacterial soft rot disease will require understanding of the pathogen at the fundamental level.

What has been done

A transposon (pCKD100) mini-Tn5 vector was used to mutagenize Pectobacterium carotovorum strain KD100. The transposon allows for the measurement of gene expression through fusion of gpf gene downstream of the truncated gene. A pool of more than 8000 mutants were tagged with the gfp gene which can be used to monitor the expression of the mutated gene. Two classes of mutants were isolated: a) mutants in genes whose expression is induced by chemical signals from host extract and b) mutants in genes whose expression is repressed by the same host extract.

Results
A transposon mutant pool of Pectobacterium carotovorum was isolated that is made up of more than 8000 individual mutants. The screen for mutants in host-signal induced and host signal repressed genes has produced candidates from each group. The mutants will be confirmed and the mutated gene identified. The role of the mutated gene in pathogenesis and host interaction will be studied. When possible management strategies will be developed from the knowledge generated.

4. Associated Knowledge Areas

KA Code	Knowledge Area
212	Pathogens and Nematodes Affecting Plants

Outcome #16

1. Outcome Measures

Define the natural enemy complex for the Brown Marmorated Stink Bug (Moore)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
{No Data Entered}

What has been done
{No Data Entered}

Results
{No Data Entered}

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants

Outcome #17

1. Outcome Measures

Engineer drought-tolerant bioenergy crops (Cheng)

Not Reporting on this Outcome Measure

Outcome #18

1. Outcome Measures

Biofuel crop enhancement through mircospore molecular marker development. (Aziz)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Sweet sorghum is resistant to salt and drought stress, contains high fermentable sugar in the stalks, and is suitable for direct fermentation in ethanol production for advanced biofuel usage. Developing advanced genetic tools to help fully exploit the potential of sweet sorghum as an energy crop will lead research efforts associated with feedstock development through adaptation of innovative marker procedures. Through molecular analyses of isolated individual gametes from sweet sorghum cultivars, information on gametophytic genes as well as polymorphic molecular markers will be developed.

What has been done
Two US sweet sorghum (Sorghum bicolor) varieties (Dale and Topper 76-6) that have high sap sugar content and are suitable for Tennessee agronomic conditions were selected for research. Microspores were isolated and genomes amplified using molecular techniques. RNA based libraries were constructed and deep-sequenced. A total of 36 miRNAs and their 18 targets were randomly selected and validated through quantitative DNA amplifications.

Results
After RNA analyses, seven simple sequence repeat markers related to sugar traits were identified. Six were found suitable for Dale and four SSRs were relevant in Topper 76-6 samples.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms

Outcome #19

1. Outcome Measures

Producers in urban settings will adopt new technology/strategies developed for vegetable production as a part of an urban agriculture project. (Nandwani)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The production of organic food in urban and semi urban settings is a challenge due to limited land, water and energy availability. The program targets urban and semi urban residents and small growers need to produce organic vegetables vertically in limited indoor or outdoor space.

What has been done
Leafy greens (kale, lettuce, chard and collard) evaluated in organic vertical systems to determine the yield expectations, sensory quality and nutritional quality. Results of two years research trials shared with the stakeholders in grower meetings statewide and at scientific conferences.

Results
Two vertical systems, vertigro and grow towers, were evaluated for vegetable production successfully. Data on the yield performance, nutritional and texture profile analysis (TPA) were collected. Results suggest that vertical growing systems are a viable alternative to growing vegetables vertically on land in controlled environment.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

Outcome #20

1. Outcome Measures

Organic growers in Tennessee will adopt new technology/strategies developed for the vegetable production. (Nandwani)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Adoption of organic farming in the Southern region poses challenges of disease and insect pest problems due to hot and humid summers. To improve sustainability, farmers use intensive production such as row covers without taking advantage of the full benefits of the technology. This project will generate research data and results available for researchers, growers and stakeholders that are well informed on available tools for crop protection and organic vegetable production.

What has been done
Low tunnels were used for the evaluation of row covers, insect net, agribon cloth and plastic for the production of four organic leafy vegetables. Two research trials conducted in fall 2017 and spring 2018.

Results

Kale, collard, Swiss chard and lettuce evaluated and data collected on plant yield and percentage of leaves affected by pest and disease. Higher yield recorded under row cover treatments compared to control (open). The pest incidence was higher (13%) in kale and (10.5%) in collards under control whereas no damage under row covers treatments recorded in all leafy green vegetables.

4. Associated Knowledge Areas

KA Code	Knowledge Area
202	Plant Genetic Resources
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

Outcome #21

1. Outcome Measures

Extension Corn Production Programs Increase Total Farm Income

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Challenges facing the row crops industry include understanding and adopting changes in technology, integrated pest management, sustainable agronomic practices and profitability. Corn was planted and harvested on more than 685,000 acres in Tennessee in 2018.

What has been done
Extension agents and area Extension specialists conducted educational programs reaching over 15,300 direct and 3.6 million indirect contacts during 2018. Best production practices were taught at more than 110 group meetings and over 530 on-farm visits.

Results
Tennessee corn producers increased yield 2,669,772 total bushels by adopting two or more recommended production practices on 328,733 acres increasing total income by $10 million.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
601	Economics of Agricultural Production and Farm Management

Outcome #22

1. Outcome Measures

Extension Soybean Production Programs Increase Total Farm Income

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Challenges facing the row crops industry include understanding and adopting changes in technology, integrated pest management, sustainable agronomic practices and profitability. Soybeans were harvested on more than 1.67 million acres in Tennessee in 2018. Excess rainfall in the spring and fall delayed planting and harvest resulting in lower yields and seed quality issues due to delayed harvest. Final state average yield was 48 bushels/acre (Jan 2018 NASS quick facts). Soybean prices were mediocre and most producers received close to $8.60 per bushel for their crop. Projected cash receipts for soybeans in 2018 are $689 million.

What has been done
Extension agents and specialists conducted educational programs reaching over 29,000 direct and 6 million indirect contacts during 2018. Best production practices were taught at more than 1000 group meetings and over 615 on-farm visits.

Results
The evaluation showed that 951 of 1425 (67%) of producers surveyed adopted two or more practices demonstrated in Extension soybean production programs. Soybean producers increased yield by 1,782,795 total bushels on 709,884 acres increasing total income by $15.3 million.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
601	Economics of Agricultural Production and Farm Management

Outcome #23

1. Outcome Measures

Extension Wheat Production Programs Increase Total Farm Income

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Challenges facing the row crops industry include understanding and adopting changes in technology, integrated pest management, sustainable agronomic practices and profitability.

What has been done
University of Tennessee Extension agents and specialists provided updated wheat variety and agronomy information to producers. This included information about how to efficiently increase wheat production on their farms. Pest-management information assisted growers in controlling pests with an integrated approach to pest management. This information was distributed to producers through 874 direct contacts and over 5400 indirect contacts through newspaper articles and other outreach activities.

Results
414 of 462 wheat producers increased knowledge of UT recommended agronomic and pest management practices and 324 of 457 producers adopted two or more of those practices. Wheat producers increased yield 680,847 total bushels by adopting two or more recommended production practices on 111,448 acres increasing total income by $3.2 million.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems

601 Economics of Agricultural Production and Farm Management

Outcome #24

1. Outcome Measures

Tennessee Extension Leads Variety Test Program for Corn Grain, Silage, and Soybeans

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Tennessee producers need information concerning corn and soybean variety test performance specific to their region so that they can select varieties that will optimize the profitability of their production systems.

What has been done
The variety test program provides important information on varieties that perform best in Tennessee. Replicated variety tests were conducted on corn grain (94 hybrids; 19 brands), corn silage (13 hybrids, 6 brands), and soybeans (205 varieties; 22 brands) at seven of UT's Research and Education Centers located in the different physiographic regions of Tennessee in 2018. Results from these crop trials were compile, along with results from the County Standard Tests (CST) and soybean disease variety trials and published in three peer-reviewed Extension publications. 4750 hard copies of the publications were distributed to farmers, extension agents, seed industry representatives, consultants and others, and publications were also accessible online.

Results
In 2018, the variety test program provided an estimated $166.4 million additional revenue to Tennessee producers. This numbers includes $29.9 million from corn and $136.4 million from soybean. These numbers were calculated by determining the monetary value of growing top performing varieties compared with varieties that exhibit average yield performance. In 2018, top performing varieties exhibited a yield advantage of +13 bu/a for corn and +6 bu/a for soybeans. The variety test program has a significant economic impact to Tennessee producers and continues to be a program that is highly valued by producers.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
205	Plant Management Systems
601	Economics of Agricultural Production and Farm Management

Outcome #25

1. Outcome Measures

Increased understanding of the role of cover crops in improving nitrogen levels in soil (Jagadamma)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
An effective and locally adaptable strategy to augment sustainable food production is cover cropping. Leguminous cover crops (e.g. hairy vetch, crimson clover, red clover) provide additional nitrogen to crops; non-leguminous cover crops (e.g. rye, wheat, oats) control soil erosion, suppress weeds and improve soil organic matter content, and tap-rooted species such as brassicas reduce soil compaction. A comparative evaluation of single-, double-, and multi-species cover crops is necessary to better understand the role of cover crops in improving nitrogen availability in soil.

What has been done
We conducted comparative field trials in Tennessee in a corn-soybean rotation system single-, double-, and multiple-species cover crops.

Results
Growing a mixture of cover crops (legumes, cereals, and brassicas) increased soil inorganic nitrogen availability more so than single- and double-species cover crops. We also found that potentially mineralizable nitrogen, which accounts for the nitrogen that becomes available throughout the growing season, was the highest from multi-species cover crop mixture and double species cereal rye-crimson clover than the cover crop free control.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
102	Soil, Plant, Water, Nutrient Relationships

Outcome #26

1. Outcome Measures

Identification of potential applications of unmanned/uncrewed airborne systems (UAS) in precision agriculture (Freeland)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Farmers and crop consultants prefer an alternative way to survey fields for diagnostic purposes that do not involve tools such as Google Earth or onsite inspections. Unmanned/uncrewed airborne systems (UAS) may be able to successfully provide real-time aerial surveys indicating situations such as erosion events and pest infestations, providing an alternative means to survey fields.

What has been done
UAS mapping methods were developed to map agricultural subsurface drainage systems. Preliminary UAS surveys with VIS, NIR, and TIR sensors were carried out at a farm field test site in central Ohio. During the UAS surveys, the soil surface was very dry (less than 5 mm of rainfall the previous week, soil surface volumetric water content below 16%, and soil surface temperature above 33°C), and the ground was partially covered with past growing season crop residue and existing early growth stage corn/soybeans.

Results
Under these field conditions, drainage pipes were not detected with the VIS and NIR imagery. Conversely, the TIR image detected roughly 60% of the subsurface drainage infrastructure known to be present. TIR imagery from UAS surveys was found to have considerable potential for

drainage pipe mapping purposes, and compared to VIS and NIR imagery, may be better suited for detecting drain line locations under dry surface conditions. However, more evaluation of VIS, NIR, and TIR imagery for drainage pipe mapping is certainly needed under different soil wetness/dryness conditions and at a number of test sites having different types of soil and drainage system characteristics.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment
404	Instrumentation and Control Systems

Outcome #27

1. Outcome Measures

Develop a genotyping tool to detect Bt resistance alleles in insects (Jurat-Fuentes)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Bt corn, a transgenic corn variety that produces insecticidal proteins from the bacterium Bacillus thuringiensis, is a safe, widely-used variety that has been used for years to control arthropod pests. Some of these pests have developed resistance to Bt corn, threatening the sustainability of this variety. Researchers must better understand Bt resistance and have the tools necessary to identify and predict it in order to ensure the future of Bt corn.

What has been done
We have identified the mutation responsible for resistance to transgenic corn producing the Cry1F insecticidal protein in Puerto Rico, which has also led to the identification of a functional receptor for Cry1F and Cry1A insecticidal proteins produced by Bt corn and Bt cotton.

Results
Based on the identified allele, we have developed a DNA-based genotyping test that detects the presence of the resistance allele FAW. This will enable a change in action by replacing current costly and less sensitive resistance monitoring methods with sensitive monitoring DNA-based

technology scalable to high throughput. The use of these genotyping tools is also expected to lead to a change in knowledge by advancing our ability to predict the movement of resistant populations to threaten corn and cotton production in the USA and provide Federal regulators with scientific data to better assess risks of specific transgenic crops for FAW resistance dispersal.

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Competing Programmatic Challenges

Brief Explanation

• Corn was harvested on more than 685,000 acres in Tennessee in 2018. The 2018 growing season was very challenging, weather wise, beginning with a wet spring followed by a growing season that included moderate to hot temperatures and more plentiful rainfall across the state. Farmers reported good corn yields although most agreed the growing season was more challenging than the previous year. The final state average yield tied the state record 173 bushels/acre (Jan 2018 NASS Quick stats). Corn prices were low due to the large U.S. crop with producers receiving closer to $3.60 per bushel for their crop on average. Projected cash receipts for 2018 corn grain in Tennessee are estimated at more than $426 million.

• Soybeans were harvested on more than 1.67 million acres in Tennessee in 2018. Excess rainfall in the spring and fall delayed planting and harvesting resulting in lower yields and seed quality issues due to delayed harvest. Final state average yield was 48 bushels/acre (Jan 2018 NASS Quick facts). Soybean prices were mediocre due to tariff issues and weak exports and most producers received close to $8.60 per bushel for their crop factoring in the tariff support payments from the government. Projected cash receipts for soybeans in 2018 are down from the previous year at $689 million.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

• Research advances in biofuel crop enhancement through mircospore molecular marker development.

• New techniques in producing vegetables for urban dwellers.

• Developed a soybean germplasm that can be screened for mutants which produce lower amounts of unsaturated fatty acids and minimizes the need for a hydrogenation step (hence, unhealthy trans-fats) in the production of soybean oil.

• Soybean germplasm developed through this project is a valuable asset in identifying mutants with potential herbicide resistance traits- this is non-GMO resistance.

In 2018, the variety test program provided an estimated $166.4 million in additional revenue to Tennessee producers. This number includes $29.9 million from corn and $136.4 million from soybean. These numbers were calculated by determining the monetary value of growing top performing varieties compared with varieties that exhibit average yield performance. Yield advantage was calculated by subtracting the test average from the average yield of top performing varieties, defined as varieties that did not differ statistically from the highest yielding variety within each test. In 2018, top performing varieties exhibited a yield advantage of +13 bu/a for corn and +6 bu/a for soybeans and these numbers were multiplied by USDA reported price per bushel and by 88% based on results from a 2017 survey that indicated 88% of respondents use the variety test results to select top performing varieties.. The variety test program has a significant economic impact to Tennessee producers and continues to be a program that is highly valued by producers.

Key Items of Evaluation

In 2018, the variety test program provided an estimated $166.4 million in additional revenue to Tennessee producers. This number includes $29.9 million from corn and $136.4 million from soybean. These numbers were calculated by determining the monetary value of growing top performing varieties compared with varieties that exhibit average yield performance. Yield advantage was calculated by subtracting the test average from the average yield of top performing varieties, defined as varieties that did not differ statistically from the highest yielding variety within each test. In 2018, top performing varieties exhibited a yield advantage of +13 bu/a for corn and +6 bu/a for soybeans and these numbers were multiplied by USDA reported price per bushel and by 88% based on results from a 2017 survey that indicated 88% of respondents use the variety test results to select top performing varieties.. The variety test program has a significant economic impact to Tennessee producers and continues to be a program that is highly valued by producers.

V(A). Planned Program (Summary)

Program # 3

1. Name of the Planned Program

Animal Systems

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
301	Reproductive Performance of Animals	15%	15%	21%	0%
302	Nutrient Utilization in Animals	0%	0%	33%	20%
303	Genetic Improvement of Animals	10%	10%	0%	30%
304	Animal Genome	0%	0%	0%	20%
305	Animal Physiological Processes	0%	0%	7%	10%
306	Environmental Stress in Animals	0%	0%	4%	0%
307	Animal Management Systems	60%	60%	10%	20%
311	Animal Diseases	15%	15%	13%	0%
315	Animal Welfare/Well-Being and Protection	0%	0%	7%	0%
722	Zoonotic Diseases and Parasites Affecting Humans	0%	0%	5%	0%
	Total	100%	100%	100%	100%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	44.0	5.0	30.0	8.0
Actual Paid	40.5	5.0	14.5	9.0
Actual Volunteer	0.5	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
815704	161842	438764	270561
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
4008445	240829	913268	384051
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
731540	52098	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

In 2018, two programs led by Tennessee Extension specialists and agents continue to strengthen animal systems in Tennessee: the Master Beef Producer Program and the Master Meat Goat Producer Program. Master Beef Producer programs are only taught by agents who have completed the comprehensive training curriculum. 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, etc. The program is designed to enhance the profitability and competitiveness of cow-calf operations through essential, technical information that included a detailed beef production manual and the opportunity for producers to interact with trained facilitators and to share ideas with other producers. The Master Meat Goal Producer Program promotes the production of goats as a natural alternative to tobacco. Tennessee continues to rank second in meat goats in the U.S. The Small Ruminant College is an annual two-day event covering a different major production theme each year. Along with the two days of both inside lectures and outside hands-on demonstrations, the attendees receive proceedings to complement the topics covered. Work will continue in working with small ruminant farmers as well as with professionals through Heifer International. Presentations and demonstrations in the state are designed for extension agents, government agencies, meat goat organizations, farmer forum initiatives, and 4-H groups.

We conducted applied and basic research in animal health, nutrition, physiology, and genomics to address high priority problems of the livestock industries. We disseminated information gained from these studies to producers, veterinarians, and others associated with the animal industries through outreach programs and publications. Examples of research projects include:

- Experiments with social v. individual housing strategies for young calves and potential short- and long-term impacts on their behavior, performance, and physiology.
- Research in order to improve livestock nutrient digestion and utilization of forages.
- Genomic studies to better understand adipose tissue and excess fat deposits in broiler chickens.
- Basic research about factors that contribute to feed efficiency in beef cattle.
- Experiments to develop effective strategies to manage mastitis in dairy cows.
- Experiments to indicate environmental factors that alter ovum quality and impair fertility.
- Develop detection and prevention methods to control Campylobacter colonizations in animal reservoirs, consequently reducing foodborne illness.
- Conduct research on the longitudinal survival and reproductive output of meat goat does.
- Conduct research on nutritional requirements for poultry and Guinea fowl.
- Perform genome mapping of important production qualities in poultry and Guinea fowl.
- Conduct focus group meetings to collect information from producers and consumers.
- Identify selected meat goat consumers/ethnic groups/communities.

- Develop antiviral agents for livestock producers.

2. Brief description of the target audience

Producers, veterinarians, and others associated with the animal industry were the target audience for this planned program. Tennessee cattle producers are primarily cow-calf operators. All of the state's cow-calf operators compose the target audience for this planned program.

Additional target audiences include dairy and meat goat producers, the national meat goat industry, institutions of meat goat research, ruminant livestock producers, students, public officials, Guinea fowl and poultry industries, small farmers, scientific community.

3. How was eXtension used?

Tennessee Extension personnel were part of the Beef Cattle, Goats and Horses Communities of Practice and they answered questions related to animal issues.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	244090	10890059	15249	140

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	37	26	63

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of exhibits displayed to promote awareness of and participation in this planned program.

Year	Actual
2018	9839

Output #2

Output Measure

- Number of research-based publications distributed as part of this program.

Year	Actual
2018	3220643

Output #3

Output Measure

- Evaluate Alternative Heating Systems for Broiler Houses (Hawkins)
  Not reporting on this Output for this Annual Report

Output #4

Output Measure

- Improve Reproductive Efficiency in Cattle (Rispoli)
  Not reporting on this Output for this Annual Report

Output #5

Output Measure

- Promote Native Grasses in Forage Systems (Keyser)
  Not reporting on this Output for this Annual Report

Output #6

Output Measure

- Improve nutrient utilization in heat-stressed lactating dairy cows (Ruis)
  Not reporting on this Output for this Annual Report

Output #7

Output Measure

- Develop novel methods of measuring temperament in bulls (Kattesh)
  Not reporting on this Output for this Annual Report

Output #8

Output Measure

- Collect and analyze samples to assess antimicrobial resistant bacteria and genes associated with dairy production systems (Pighetti)

Year	Actual
2018	80

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Extension Economic Impact: The total economic impact of Extension animal systems programs. (The target is expressed in millions of dollars.)
2	Beef Production and Marketing: Number of beef producers who utilized improved sires, artificial insemination or other genetic improvement methods.
3	Beef Production and Marketing: Number of beef producers who improved marketing methods.
4	Beef Production and Marketing: Number of producers who improved forages for livestock by broadleaf weed control, planting clover, stockpiling fescue or planting warm-season grasses.
5	Beef Production and Marketing: The number of calves managed according to Beef Quality Assurance (BQA) guidelines.
6	Goat Production: Number of goat producers who have implemented practices related to genetic improvement, nutrition, health, reproduction and other information as a result of the Master Goat Program.
7	Develop Diagnostic Devices for Animal/Human Diseases (Eda)
8	Supplement Nutrients for Improved Reproduction (Mulliniks)
9	Research to provide new information on the benefit of a new sire breed option (Savannah) and creep feeding on improving the doe output and economic return for commercial meat goat enterprises. (Browning)
10	Efficiency of feed utilization in poultry through knowledge and implementation of optimum nutrient requirements, especially methionine and cysteine. (Nahashon)
11	Genetic resource information for future and rapid selection of well performing animals and those that can transmit superior economic traits to future generations. (Nahashon)
12	Discovery of modes of action of probiotics and new nutrient sensing pathways leading to establishment of precise nutrient requirements of poultry, especially chickens and guinea fowl. (Nahashon)
13	Research to enhance income for meat goat producers through increased consumer knowledge about goat meat and retailer knowledge of goat meat preferences. (Ekanem)
14	Enhanced producer knowledge of marketing information to expand goat meat sales to existing markets. (Ekanem)
15	Efficacy of fat deposition reduction in poultry through genotyping by sequencing approach for analysis of chicken genome. (Wang)
16	Research intestinal microbiota as alternatives to antibiotic growth promoters for food animals and to combat human obesity (Lin)
17	Address S. aureus as causative agent of mastitis (Dego)

18	Develop Non-Antibiotic Strategies for Dairy Cattle Mastitis (Almeida, Prado, Luther)
19	The efficacy of direct-fed microbials to improve efficiency of feed utilization and growth performance in poultry (Nahashon)
20	Basic and applied research in innate immune interferons to develop novel antiviral therapeutics for the livestock industry (Sang)
21	Increasing Returns for Tennessee Equine Owners through Extension Programs
22	Dairy Producer Program Improves Producers Knowledge of Milk Quality
23	Increased understanding of environmental factors that affect ovum quality and lead to infertility in ruminants (Edwards)
24	Increased understanding of adipose tissue in broiler chickens (Voy)

Outcome #1

1. Outcome Measures

Extension Economic Impact: The total economic impact of Extension animal systems programs. (The target is expressed in millions of dollars.)

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	3461

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
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 cots. Nutritional, reproductive, genetic, and health management are the general areas that impact profitability the most.

What has been done
UT Extension agents and specialists spent 32,859 hours conducting educational programs that reached 192,148 direct contacts during 2018. Best management practices in beef cattle

production were taught at 2,107 group meetings, 2,135 on-site visits and 4,630 walk-in consultations in local county offices. Research and impact as measured by direct contacts remained relatively stable compared to 2017 in all reported categories. Mail, telephone and electronic communications reached 96,954 contacts. These methods were reinforced by 355 social media posts, 299 newspaper articles, 93 radio programs, and 8 television programs reaching an estimated 7.8 million indirect contacts. Volunteers invested 737 hours of their personal time to establish a total of 10,451 direct and indirect contacts.

Results

The total economic impact of UT Extension's beef cattle programming was estimated at more than $49.3 million in savings and additional revenue as measured by:
-3,461 beef producers sold 148,301 calves that were managed for improved marketing methods according to practices promoted by UT Extension to increase returns by $10,825,973.
-1,982 beef producers utilized 4,451 bulls (through natural service or artificial insemination) with greater genetic potential to produce 111,849 head of calves to increase returns by $5,592,450.
-2,008 beef producers implemented reproductive management by conducting breeding soundness exams on 3,188 bulls ($15,940,000 increased returns) and pregnancy diagnosis on 42,288 cows/heifers ($16,915,200 increased returns).
Adoption of modern technologies for reproductive management decreased slightly from that reported in the previous year. However, these practices still have dramatic impact on the profitability of beef cattle production. Thus, county agents focused on increasing adoption of those practices that is evident in the dramatically positive financial impact reported here. In 2018, UT Extension programming for beef cattle production and management continued to enhance the lives and livelihood of Tennessee beef cattle producers.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems

Outcome #2

1. Outcome Measures

Beef Production and Marketing: Number of beef producers who utilized improved sires, artificial insemination or other genetic improvement methods.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	2982

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
303	Genetic Improvement of Animals

Outcome #3

1. Outcome Measures

Beef Production and Marketing: Number of beef producers who improved marketing methods.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	3461

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems

Outcome #4

1. Outcome Measures

Beef Production and Marketing: Number of producers who improved forages for livestock by broadleaf weed control, planting clover, stockpiling fescue or planting warm-season grasses.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
More efficient forage production will contribute to improved profitability for Tennessee forage producers.

What has been done
UT Extension conducted forage educational programs reaching over 28,000 direct contacts during 2018. 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 over 780 on-site visits. These direct contacts were supported by over 100 newspaper articles and 36 radio and TV programs.

Results
On-farm interviews and surveys were used to evaluate these programs. Impacts were:
-Producers planted 51,189 acres with clover for an increased production valued at $1,279,000.
-Producers planted 24,387 acres with warm-season grasses for an added value of $488,000.
-Producers fed 97,878 cattle with improved hay feed practices, saving $2.4 million.
-Producers stockpiled 50,101 acres of tall fescue, reducing feeding cost by $2.4 million.

4. Associated Knowledge Areas

KA Code	Knowledge Area
302	Nutrient Utilization in Animals
307	Animal Management Systems

Outcome #5

1. Outcome Measures

Beef Production and Marketing: The number of calves managed according to Beef Quality Assurance (BQA) guidelines.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	3461

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems

Outcome #6

1. Outcome Measures

Goat Production: Number of goat producers who have implemented practices related to genetic improvement, nutrition, health, reproduction and other information as a result of the Master Goat Program.

2. Associated Institution Types

- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	561

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of Animals
302	Nutrient Utilization in Animals
303	Genetic Improvement of Animals
307	Animal Management Systems
311	Animal Diseases

Outcome #7

1. Outcome Measures

Develop Diagnostic Devices for Animal/Human Diseases (Eda)

Not Reporting on this Outcome Measure

Outcome #8

1. Outcome Measures

Supplement Nutrients for Improved Reproduction (Mulliniks)

Not Reporting on this Outcome Measure

Outcome #9

1. Outcome Measures

Research to provide new information on the benefit of a new sire breed option (Savannah) and creep feeding on improving the doe output and economic return for commercial meat goat enterprises. (Browning)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Producers need to better assess the ability of breeds to contribute to efficient market kid production under limited inputs. Many producers have made poor breed choices that have led to non-sustainable operations. Creep-feeding in meat goat systems has often been recommended and implemented without sufficient research to support the recommendation.

What has been done
Savanna bucks have been compared to Kiko and Spanish bucks for preweaning progeny performance. Kids born were either creep-fed or not provided creep feed to assess growth and economic outcomes. Presentations and research updates were disseminated to at industry events and academic meetings.

Results
Research outcomes indicated that Savanna sires did not demonstrate an advantage over Kiko or Spanish sires for kid performance. Creep feeding enhanced kid growth, but did not enhance net economic return. Dam performance was not impacted. There was some indication that creep feeding improved indicators of internal parasitism among certain groups of dams and kids. Dissemination of results have allowed novice and experienced producers to better understand how breed selection and creep-feeding affects commercial meat goat herd outcomes.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems

Outcome #10

1. Outcome Measures

Efficiency of feed utilization in poultry through knowledge and implementation of optimum nutrient requirements, especially methionine and cysteine. (Nahashon)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Methionine and cysteine are essential amino acids for growth performance of poultry; however, the requirement for these amino acids for optimum growth performance of the guinea fowl is not known. Lack of optimal dietary amino acid profiles can hamper growth performance and increase cost of poultry production.

What has been done
The methionine and cysteine requirement for optimum growth performance of the guinea fowl was evaluated.

Results
In a repeat trials, the methionine and cysteine requirement for optimal growth performance of the French guinea fowl broiler at 0-4 weeks of age was 0.50% and 0.40%, respectively. However, at 5-8 WOA, the optimal dietary methionine and cysteine for these birds seem to be 0.45%.

4. Associated Knowledge Areas

KA Code	Knowledge Area
302	Nutrient Utilization in Animals
303	Genetic Improvement of Animals
304	Animal Genome

Outcome #11

1. **Outcome Measures**

Genetic resource information for future and rapid selection of well performing animals and those that can transmit superior economic traits to future generations. (Nahashon)

Not Reporting on this Outcome Measure

Outcome #12

1. **Outcome Measures**

Discovery of modes of action of probiotics and new nutrient sensing pathways leading to establishment of precise nutrient requirements of poultry, especially chickens and guinea fowl. (Nahashon)

Not Reporting on this Outcome Measure

Outcome #13

1. **Outcome Measures**

Research to enhance income for meat goat producers through increased consumer knowledge about goat meat and retailer knowledge of goat meat preferences. (Ekanem)

Not Reporting on this Outcome Measure

Outcome #14

1. **Outcome Measures**

Enhanced producer knowledge of marketing information to expand goat meat sales to existing markets. (Ekanem)

Not Reporting on this Outcome Measure

Outcome #15

1. **Outcome Measures**

Efficacy of fat deposition reduction in poultry through genotyping by sequencing approach for analysis of chicken genome. (Wang)

Not Reporting on this Outcome Measure

Outcome #16

1. Outcome Measures

Research intestinal microbiota as alternatives to antibiotic growth promoters for food animals and to combat human obesity (Lin)

Not Reporting on this Outcome Measure

Outcome #17

1. Outcome Measures

Address S. aureus as causative agent of mastitis (Dego)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Each year dairy cattle producers lose billions of dollars due to reduced milk production and low-quality milk resulting from mastitis - an infection of the mammary gland that causes inflamed, sore udders. This infection is highly contagious. Control of mastitis would improve animal health and increase profitability for producers. One approach to this disease management is the development of a novel vaccine to control Staphylococcus aureus - a common cause of chronic mastitis.

What has been done
We evaluated the ability of cattle sera to cross-react with surface proteins from nine genetically distinct strains of S. aureus previously isolated from mastitis. Multiple immuno-reactive surface proteins were common across the strains. We evaluated the ability of surface proteins from S. aureus (SASP) and Staphylococcus chromogenes (SCSP) to serve as vaccine agents to boost antibody titers and protect against S. aureus infection when cows were exposed daily using a dip challenge model. We evaluated the protective effects of Staphylococcus chromogenes surface proteins (SCSP) as vaccine antigens to control mastitis during early lactation.

Results
The SCSP vaccine cross-protected vaccinated cows from S. aureus clinical mastitis, reduced number of bacterial shedding in milk and somatic cell counts showing its promising immunogenic potential to control mastitis in dairy cows.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems
311	Animal Diseases

Outcome #18

1. Outcome Measures

Develop Non-Antibiotic Strategies for Dairy Cattle Mastitis (Almeida, Prado, Luther)

Not Reporting on this Outcome Measure

Outcome #19

1. Outcome Measures

The efficacy of direct-fed microbials to improve efficiency of feed utilization and growth performance in poultry (Nahashon)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The gastrointestinal tract is an enormous surface inhabited by a complex and diverse community of microorganisms known as the intestinal microflora. Our laboratory characterized some of these microorganisms and now evaluating their potential to improve bird growth performance by enhancing health and nutrient utilization. They also have the potential to substitute antibiotics and minimize antimicrobial resistance in poultry.

What has been done
Three dietary treatments containing two probiotic bacteria L. reuteri and S. coelicolor individually at 100ppm, and mixture of the two bacteria at 50ppm each were evaluated for their potential to enhance growth performance of broiler chickens.

Results
Chickens fed diets containing L. reuteri and S. coelicolor mixture showed improved body weight gain, feed consumption, and decreased feed conversion ratios. This research suggests that L. reuteri and S. coelicolor have the potential to constitute probiotics in chickens combined or separately depending on the desired selection of performance index.

4. Associated Knowledge Areas

KA Code	Knowledge Area
302	Nutrient Utilization in Animals
303	Genetic Improvement of Animals
305	Animal Physiological Processes

Outcome #20

1. Outcome Measures

Basic and applied research in innate immune interferons to develop novel antiviral therapeutics for the livestock industry (Sang)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Research examines a group of antiviral molecules that play a defense role in all livestock species and potentially to develop into an effective measure against viral diseases. In addition, the general public should be concerned due to the zoonotic fact that most viral diseases, such as flu and Zika, exist in livestock animals.

What has been done
Cross-species genome-wide gene annotation and phylogenic analyses to determine the evolutionary relationship of antiviral genes in livestock species have been completed.

Results
A functional study using porcine interferons is complete. We also comparatively generated several sets of genome-wide transcriptomic data as well as family-wide expression confirmation. The antiviral and immunomodulatory activity of some unconventional antiviral molecules have been determined against several devastating animal virues. Major results have been disseminated in several journal publications and reported in scientific conferences and symposia.

4. Associated Knowledge Areas

KA Code	Knowledge Area
303	Genetic Improvement of Animals
304	Animal Genome

Outcome #21

1. Outcome Measures

Increasing Returns for Tennessee Equine Owners through Extension Programs

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	175

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The equine industry has an impressive economic and agricultural impact to Tennessee. Currently, the equine industry contributes over $21 million to Tennessee's economy each year and is home to 112,000 horses, ponies, mules, donkeys and burros. With over 41,000 equine operations accounting for nearly 30% of Tennessee's agricultural acreage, UT Equine Extension programs are essential to sustainable agriculture in the state.

What has been done
An integrated, multi-disciplinary extension and applied research program is being cultivated through newly established programs along with grassroots efforts to unify equine owners, business operators, industry members, and stakeholders. In 2018, county meetings, field days, on-farm/onsite visits, news articles, publications, college-level course, personal contacts and an educational website were used to promote adoption of recommended equine management practices. Additionally, the Tennessee Master Horse Program continued this year with 5

independent programs offered to provide an unbiased science-based statewide educational program for equine owners, business operators and enthusiasts.

Results

The combined economic impact of Extension programs for Tennessee equine owners was $1,422,910 in 2018. Individual savings based on management practices are listed below:
-162 equine owners fed 532 equids according to recommended nutritional requirements and practices, such as adjusting rations based on body condition score and using forage testing to make feeding adjustments saving $155,610 annually.
-175 equine owners follow recommended health practices (including deworming, vaccination, hoof and dental preventive care) on 551 equids saving $1,267,300 annually.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems

Outcome #22

1. Outcome Measures

Dairy Producer Program Improves Producers Knowledge of Milk Quality

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Dairy production in Tennessee faces one of the primary issues of dairy production across the nation, which is loss of dairy farms. This is a critical issue as it was previously estimated that for each dollar of profit a dairy farm generates an additional $5-7 dollars are generated within the local economy. With an average of roughly 100 cows, a typical Tennessee dairy farm will contribute over a million dollars to the surrounding economy. Some of the main challenges to Tennessee farms and their survivability are milk quality, efficiency of production, and cost of production. Grazing and calf management may provide opportunities to address these issues.

What has been done

During 2018, extension agents and specialists engaged dairy producers with research-based education efforts through group meetings, on-site/farm visits and mail, phone calls and emails.

Results

Outcomes included:
-32 dairy producers used improved calf rearing techniques including group housing and increased milk allotment
-61 dairy producers increased milk production and quality following UT Extension recommended practices dealing with parlor procedures and cow comfort/housing
-20 producers have gained knowledge on measures of milk quality indicators (including somatic cell count, preliminary incubation count, lab pasteurized counts, etc.)
-20 producers have learned the relationship between somatic cell counts and milk production
-20 producers have increased awareness of effective mastitis prevention and control programs

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems

Outcome #23

1. Outcome Measures

Increased understanding of environmental factors that affect ovum quality and lead to infertility in ruminants (Edwards)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Infertility in agriculturally-important animals compromises food production systems both economically and in efficiency. Researchers need to better understand the environmental factors that affect the ovum quality and impair fertility in ruminants in order to develop management strategies and improve pregnancy success. These findings may be applicable to other animals as well as humans.

What has been done

We conducted experiments to examine consequences of an acute heat stress and the influence of certain hormones on the thermoregulatory responses of lactating cows. The cows were maintained at a temperature-humidity index (THI) of 65.9 ± 0.2 (thermoneutral) or exposed to changes in THI to simulate what may occur during an acute heat stress event (71 to 86 THI; heat stress); cows were rapidly cooled thereafter. Mixed model regressions with repeated measures were used to test respiration rates (RR) and rectal temperature (RT).

Results

Within 40 and 110 min of increasing THI, RR increased in a quadratic fashion (P < 0.001); RT increased by 0.04 ± 0.1°C (P < 0.001) per unit THI. Changes in RR lagged THI and preceded rises in RT. Average THI 3-days before treatment (prior THI) influenced RR (P = 0.050) and RT (P < 0.001) changes. Increased RR was more noticeable in heat-stressed cows when prior THI was in the 40s. Rectal temperature of heat-stressed cows was 0.8± 0.02°C lower when prior THI was in the 40s versus low 60s. Levels of progesterone and luteinizing hormone before treatment were predictive of thermoregulatory response in heat-stressed cows. Rapid cooling decreased RR by 0.6 ± 0.1bpm (P < 0.001) and RT by 0.02 ± 0.002°C per min (P < 0.002). Speed and magnitude of thermoregulatory changes to an acute heat stress and after sudden cooling emphasizes importance of strategic cooling before ovulation. Efforts to do so when prior THI approaches levels expected to induce mild stress are especially important. Respiration rate is a useful indicator of the degree of hyperthermia a lactating cow is experiencing.

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of Animals

Outcome #24

1. Outcome Measures

Increased understanding of adipose tissue in broiler chickens (Voy)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Domestic broiler chickens rapidly accumulate excess fat, essentially wasting the feed consumed to produce that access fat and increasing production costs. Better understanding adipose tissue in broiler chickens may lead to changes in their genetics and diets, resulting in less fat accumulation and improved cost efficiency for producers.

What has been done

The hypothesis guiding our current research is that the lipid component of the diet, either in chicks or in hens, can be manipulated to limit fatness in broilers. We investigated maternal programing by dietary fatty acids, and the potential to manipulate chick growth and body composition through the diet of the hen. Previously, we demonstrated that enriching the hen diet in fish oil, relative to corn oil, reduced adiposity in broiler chicks up to at least 14 days after hatch. We performed RNAseq of abdominal adipose tissue from these chicks at 7 and 14 days of age, to identify cellular pathways that contribute to reduced adipose deposition.

Results

Maternal fish oil significantly affected sets of genes involved in cellular growth and differentiation, as well as lipid metabolism. Several of the genes that responded to maternal fish oil have been shown to play roles in obesity in other species. This dataset provides a foundation from which to develop and test follow-on hypotheses to address the mechanism through which maternal dietary fat source can alter body composition in chicks. Our work suggests that the chick genome can be programmed in a way that reduces fat deposition, and raises questions about the role of the hen diet in epigenetic control of chick metabolism.

4. Associated Knowledge Areas

KA Code	Knowledge Area
305	Animal Physiological Processes

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Competing Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

The financial impact of Extension animal systems programming fluctuates from year-to-year depending on several factors including commodity prices, public policy, input costs, and land value. Extension animal systems programs continue to enhance the lives and livelihoods of Tennessee farmers.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

- Improved feed utilization in poultry through the use of probiotics and new

recommended dietary concentrations of methionine and cysteine.

- Antiviral and immunomodulatory activity of some unconventional antiviral molecules have been determined against several devastating animal virues.
- Identified a novel group of animal antiviral molecules and are validating for their antiviral or immunomodulatory activity, which will facilitate to develop them into research reagents and antiviral agents.

Extension agents optimized animal production through emphasis on quality assurance, reproductive management, nutrition and marketing with Tennessee beef producers with an economic impact of more than $49.3 million. Tennessee horse owners depend on UT Extension's research-based programs for horse health and nutrition. UT Extension taught rotational grazing to increase forage production, vaccinations, dental care, and correct deworming practices. These practices helped 175 equine owners to save $1.4 million.

Key Items of Evaluation

Extension agents optimized animal production through emphasis on quality assurance, reproductive management, nutrition and marketing with Tennessee beef producers with an economic impact of more than $49.3 million. Tennessee horse owners depend on UT Extension's research-based programs for horse health and nutrition. UT Extension taught rotational grazing to increase forage production, vaccinations, dental care, and correct deworming practices. These practices helped 175 equine owners to save $1.4 million.

V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Childhood Obesity

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
502	New and Improved Food Products	0%	0%	0%	50%
701	Nutrient Composition of Food	5%	5%	0%	0%
703	Nutrition Education and Behavior	95%	85%	0%	0%
704	Nutrition and Hunger in the Population	0%	0%	0%	50%
806	Youth Development	0%	10%	0%	0%
	Total	100%	100%	0%	100%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	75.0	9.0	0.0	6.0
Actual Paid	67.5	9.0	0.0	4.5
Actual Volunteer	4.9	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
1352875	278469	0	135281
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
6648152	419986	0	192025
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
6147845	88546	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Extension obesity prevention programs emphasize nutrition and physical activity to help prevent and reduce obesity. Programs emphasize the following:

- increasing consumption of fruits and vegetables
- increasing consumption of whole grains
- decreasing consumption of solid sugars and added fats (SoFAs)
- decreasing consumption of sugar-sweetened beverages
- increasing time spent in physical activity
- decreasing sedentary behavior

Research areas include developing alternative foods for increased nutrition among underserved populations and establish the fundamental mechanism by which cost-effective, naturally available compounds can promote health and extend lifespan in humans.

2. Brief description of the target audience

Tennesseans targeted include consumers, youth, and parents/caregivers of youth. Because of the prevalence of obesity in the state, all consumers are potentially members of the target audience. However, the Tennessee Nutrition Education Program (TNCEP) and Expanded Food and Nutrition Education Program (EFNEP) programs will be targeted to the state's limited resource population. In addition, the TSU Food Nutrition Education Program was targeted to eligible low-income youth and adult audiences.

3. How was eXtension used?

Tennessee Extension professionals were members of several eXtension Communities of Practice that related to childhood obesity in 2018. These included Families, Food and Fitness CoP, Healthy Food Choices in Schools CoP, and Community, Local and Regional Food Systems CoP. In addition, they answered questions related to childhood obesity issues.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	254771	4207098	252283	2561909

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	22	3	25

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of exhibits displayed to promote program awareness and participation.

Year	Actual
2018	1988

Output #2

Output Measure

- Number of research-based publications distributed as part of this program.

Year	Actual
2018	300016

Output #3

Output Measure

- Number of flavonoids examined for reducing oxidative stress in fibroblast cells.

Year	Actual
2018	0

Output #4

Output Measure

- Number of flavanoids examined for adipocyte differentiate efficiency in fibroblast cells.

Year	Actual
2018	0

Output #5

Output Measure

- Number of focus groups held to determine perceived benefits, value and needs for relationships by probing habits, needs, preferences, values and lifestyles associated with food and media.

Year	Actual

2018	0

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Tennessee Shapes Up: Number of participants who decreased consumption of high-fat foods such as chips, fast food, fried foods, sausage, bacon, bologna, hot dogs, etc.
2	Tennessee Shapes Up: Number of participants who decreased consumption of high-sugar foods and sweetened beverages, such as soft drinks, Kool Aide type beverages, sweetened tea, etc.
3	Tennessee Shapes Up: Number of participants who increased consumption of fruits.
4	Tennessee Shapes Up: Number of participants who increased consumption of vegetables.
5	Tennessee Shapes Up: Number of participants increased consumption of whole grains.
6	Public acceptance of soy fiber fortified breads for increased fiber consumption. (Wu)
7	Establish the fundamental mechanism by which cost-effective, naturally available compounds can promote health and extend lifespan in humans.(Si)
8	A Study of Health Promoting Components in Pigeon Pea and Its Application in Food Models (Wu)

Outcome #1

1. Outcome Measures

Tennessee Shapes Up: Number of participants who decreased consumption of high-fat foods such as chips, fast food, fried foods, sausage, bacon, bologna, hot dogs, etc.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1417

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
703	Nutrition Education and Behavior

Outcome #2

1. Outcome Measures

Tennessee Shapes Up: Number of participants who decreased consumption of high-sugar foods and sweetened beverages, such as soft drinks, Kool Aide type beverages, sweetened tea, etc.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	2472

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
703	Nutrition Education and Behavior

Outcome #3

1. Outcome Measures

Tennessee Shapes Up: Number of participants who increased consumption of fruits.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	8581

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
703	Nutrition Education and Behavior

Outcome #4

1. Outcome Measures

Tennessee Shapes Up: Number of participants who increased consumption of vegetables.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	7943

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
703	Nutrition Education and Behavior

Outcome #5

1. Outcome Measures

Tennessee Shapes Up: Number of participants increased consumption of whole grains.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	4839

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
703	Nutrition Education and Behavior

Outcome #6

1. Outcome Measures

Public acceptance of soy fiber fortified breads for increased fiber consumption. (Wu)

Not Reporting on this Outcome Measure

Outcome #7

1. Outcome Measures

Establish the fundamental mechanism by which cost-effective, naturally available compounds can promote health and extend lifespan in humans.(Si)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
More and more adults are obese, and have muscle dysfunction, which may contribute to the accelerating of aging process and decrease of quality of our daily life.

What has been done
Aging-reduced protein expressions in the muscle were reversed by treatment. Tissues have been used for RNA sequence and metabolome analysis.

Results
Cocoa epicatechin intake affects some aging-related genes expressions. Dietary cocoa intake improves lipids and protein metabolism in mice. Cocoa supplementation improves skeletal muscle function in mice. One peer-review journal article has been published and one more manuscript has been submitted. Two PhD students worked on this project are expected to graduate in May 2019

4. Associated Knowledge Areas

KA Code	Knowledge Area
704	Nutrition and Hunger in the Population

Outcome #8

1. Outcome Measures

A Study of Health Promoting Components in Pigeon Pea and Its Application in Food Models (Wu)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Chronic diseases and poverty are interconnected in a vicious cycle. It is important to introduce healthy ingredients and products to low-income communities for chronic disease prevention. Pigeon pea has been used as a traditional remedy for various disease treatments including anti-cancer, anti-inflammation, and anti-diabetes; it is also a good source for protein and fiber. Introduction of emerging crop in the Southern US may be an exceptional source of healthy ingredients. At present, very few studies are available on the health-promoting effects of Pigeon pea.

What has been done
Bioactive components in pulse seeds are getting increased attention in recent years. An investigation of the phytochemical profile and antioxidant activity of Pigeon pea flour has been completed.

Results
Phytochemical profile, antioxidant, antidiabetic, and anti-inflammatory properties of two pigeon pea varieties were investigated and compared employing colorimetric methods. Extracts of whole seeds were analyzed for quantification of (TPC) total phenolic content, (TFC) total flavonoid content, (CTC) condensed tannin content, (TSC) total saponin content. The data indicated that Georgia-2 (GA-2) exhibited higher phytochemical values than W-1. There was no significant difference between two varieties in terms of (PAC) phytic acid content for GA-2 and W-1 respectively.

4. Associated Knowledge Areas

KA Code	Knowledge Area
502	New and Improved Food Products

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Programmatic Challenges

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Research indicates a persuasive potential of using Pigeon pea in healthy food applications for antioxidant, anti-diabetic, and anti-inflammatory effects.
UT and TSU Extension evaluated Childhood Obesity programs through a combination of surveys, observations, and interviews. Our evaluation demonstrated increases in healthy food preparation, healthy food consumption, physical activity, and food resource management--all practices that can help reduce caloric intake and promote healthy behaviors.
Tennessee Extension programs helped Tennesseans prepare healthy foods and make dietary improvements

- 85% (1,150 of 1,346) reported using healthy food preparation techniques such as cooking without added salt
- 75% (1,053 of 1,411) reported cooking meals at home
- 88% (324 of 369) reported being able to modify a recipe to make it healthier
- 63% (3,000 of 4,766) reported increased intake of whole grains
- 53% (4,791 of 9,028) reported increased intake of vegetables
- 52% (4,726 of 9,126) reported increased intake of fruits
- 75% (1,636 of 2,195) reported consuming fewer foods and beverages that are high in sugar
- 81% (1,756 of 2,171) use the food label to make healthier choices

Key Items of Evaluation

Tennessee Extension programs were evaluated through surveys with demonstrated results that showed participants reported increased ability to prepare healthy foods and make dietary improvements:

- 85% (1,150 of 1,346) reported using healthy food preparation techniques such as cooking without added salt
- 75% (1,053 of 1,411) reported cooking meals at home
- 88% (324 of 369) reported being able to modify a recipe to make it healthier

- 63% (3,000 of 4,766) reported increased intake of whole grains
- 53% (4,791 of 9,028) reported increased intake of vegetables
- 52% (4,726 of 9,126) reported increased intake of fruits
- 75% (1,636 of 2,195) reported consuming fewer foods and beverages that are high in sugar
- 81% (1,756 of 2,171) use the food label to make healthier choices
-

V(A). Planned Program (Summary)

Program # 5

1. Name of the Planned Program

Economic Infrastructure and Commerce

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
308	Improved Animal Products (Before Harvest)	0%	0%	14%	0%
601	Economics of Agricultural Production and Farm Management	30%	30%	8%	20%
602	Business Management, Finance, and Taxation	5%	5%	14%	20%
603	Market Economics	5%	5%	7%	40%
604	Marketing and Distribution Practices	30%	30%	0%	20%
605	Natural Resource and Environmental Economics	0%	0%	14%	0%
606	International Trade and Development	5%	5%	7%	0%
607	Consumer Economics	10%	10%	0%	0%
608	Community Resource Planning and Development	15%	15%	15%	0%
609	Economic Theory and Methods	0%	0%	14%	0%
610	Domestic Policy Analysis	0%	0%	7%	0%
	Total	100%	100%	100%	100%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	32.0	7.0	35.0	2.0
Actual Paid	31.5	7.0	11.8	6.5
Actual Volunteer	0.2	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
636647	202722	603888	195405
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
3128542	305694	871289	277370
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
235582	64450	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

To evaluate the impacts of various policies, management strategies, or economic conditions on a farm's bottom line and financial strength, we are developing a set of representative farms that encompass major segments of agriculture in Tennessee. Methods for evaluating risk include risk-based econometric models, risk-based mathematical programming models, generalized stochastic dominance criteria, dynamic optimization, and subjective probability assessment criteria. In 2018, UT Extension developed economic impact of agriculture bulletins for all 95 Tennessee counties. In addition, a publication was created to help stakeholders understand how the impacts were generated. At the request of the Tennessee Department of Agriculture, UT Extension faculty also generated and presented information about agricultural impacts as a percentage of all local economic activity for each county in Tennessee. These activities provided county extension personnel with a useful advocacy tool for working with local government and local business leaders.

The Extension MANAGE program helps families analyze their total farming business so they can make informed decisions regarding their future. Extension staff trained in farm and financial management help families to review their current financial situation, develop individualized farm and financial plans, and determine appropriate production practices. In addition to individualized farm and financial planning assistance, Extension offers workshops to help farmers improve their financial situation that include information about improved marketing, goal-setting, and strategic planning.

Land is a great source of wealth in the African-American community. In addition to providing economic stability, land ownership is highly correlated to one's social and economic well-being. Many urban residents who desire to return to the land of their origin find themselves confronted by various obstacles in terms of retaining rightful land ownership. In addition to problems they face of landownership retention are efforts to engage in profitable land use development, and operate viable farming enterprises.

Research projects focused on the factors that influence the international competitiveness of the U.S. food and agriculture sector; analyses of the economic impacts of and opportunities for value-added agriculture and forest products; government and industry led marketing programs; econometric analysis of biosecurity data to estimate the factors contributing to beef cattle producers' adoption and impact of disease preventative measures; evaluation of the factors influencing financial performance and long-term sustainability of the food and agribusiness sector.

Other research activities include advancing the sustainability of small farm enterprises via diversification strategies, promoting the growth of the Tennessee viticulture industry by determining the impact of production designations, and assessing agricultural entrepreneurship of small farmers.

2. Brief description of the target audience

- Limited-resource and small farmers

- Farmers transitioning from tobacco to other crops
- Policy-makers at the state, federal, and municipal level
- Businesses looking to expand or relocate to Tennessee

3. How was eXtension used?

Tennessee Extension personnel annually address Frequently Asked Questions through eXtension including questions about economic infrastructure and commerce.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	160230	3149060	17274	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	95	19	114

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of exhibits displayed to promote program awareness and participation.

Year	Actual
2018	133

Output #2

Output Measure

- Number of research-based publications distributed as part of this program.

Year	Actual
2018	20226

Output #3

Output Measure

- Perform economic analyses of various industries and agricultural practices (Jensen)
  Not reporting on this Output for this Annual Report

Output #4

Output Measure

- Promote local food production and consumption (Hellwinckel)
  Not reporting on this Output for this Annual Report

Output #5

Output Measure

- Provide forward looking economic analysis for Tennessee (English)
  Not reporting on this Output for this Annual Report

Output #6

Output Measure

- Evaluate economic resilience of agriculture and water use efficiency (Clark, Lambert)
  Not reporting on this Output for this Annual Report

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Land Ownership Information Program: Number of African-American landowners who increased their knowledge of property rights and responsibilities.
2	Land Ownership Information Program: Number of African-American landowners who developed farm management plans.
3	Land Ownership Information Program: Number of African-American landowners who developed estate plans to reduce the financial and legal risks farm family businesses face as they transition between generations.
4	Farm Financial Analysis and Planning: Number of farm families and rural business operators who implemented partial budgeting decisions (examples include sell calves now or later and evaluating equitable leasing arrangements)
5	Farm Financial Analysis and Planning: Number of farm families who developed whole farm plans to improve their farm financial performance.
6	Tennessee Extension Leadership Development: Small businesses or non-profits developed by limited resource leaders.
7	Assess the Local Food System/the Knoxville Foodshed (Hellwinckel)
8	Promote the growth of the Tennessee viticulture industry by determining the impact of production designations (eco-labeling and other certifications) on consumer perception, preference and willingness to pay. (Kar)
9	Evaluate bioenergy economics (Yu, Jensen, Lambert, English)
10	Advance the sustainability of small farm enterprises through assessment of income risks and the role of diversification strategies among small farms in Tennessee and the United States. (Khanal)
11	Assessing Agricultural Entrepreneurship in Relation to Small Farmers (Tegegne)
12	Increase fruit and vegetable producers' understanding of factors that impact their marketing strategies and product pricing for direct-to-consumer outlets (Velandia)
13	Increased understanding of producers' willingness to pay for increased biosecurity measures (Thompson)
14	Improved understanding of potential for biofuels and associated feedstocks expansions (Jensen)

Outcome #1

1. Outcome Measures

Land Ownership Information Program: Number of African-American landowners who increased their knowledge of property rights and responsibilities.

2. Associated Institution Types

- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management

Outcome #2

1. Outcome Measures

Land Ownership Information Program: Number of African-American landowners who developed farm management plans.

2. Associated Institution Types

- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	15

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
limited resource minority land owners have difficulty in securing loans and other governmental funds/support due to their lack of record keeping. TSU New farmer academy assisted all participants including the African American landowners to develop a farm management plan under the guidance of our UT/TSU Extension farm management specialists.

What has been done
African-American landowners who participated in TSU Extension New Farmer Academy were trained to develop their individual farm management plans.

Results
Five African American landowners who participated in TSU New Farmer Academy and developed their farm management plans were able to secure federal and state government support for their operations.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
608	Community Resource Planning and Development

Outcome #3

1. Outcome Measures

Land Ownership Information Program: Number of African-American landowners who developed estate plans to reduce the financial and legal risks farm family businesses face as they transition between generations.

2. Associated Institution Types

- 1890 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
There is a significant number of African-American landowners that have or are close to retirement age and face the difficulty or legal risks of losing their farms but interested in transitioning it to their family members or other relatives. The lack of knowledge in estate planning is a big concern for aging African-American farmers in Tennessee.

What has been done
TSU Extension outreach conferences were held to reach out limited resource, minority and women landowners to provide educational assistance in their individual needed areas. In addition, TSU New farmer Academy was expanded to middle, eastern and western Tennessee counties to reach out limited resource and minority landowners and farmers.

Results
All participants in the TSU outreach conferences and New farmer academy learned about estate planning. Two African-American landowners prepared and transitioned their land to their family member or other neighbor.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
608	Community Resource Planning and Development

Outcome #4

1. Outcome Measures

Farm Financial Analysis and Planning: Number of farm families and rural business operators who implemented partial budgeting decisions (examples include sell calves now or later and evaluating equitable leasing arrangements)

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	240

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management

Outcome #5

1. Outcome Measures

Farm Financial Analysis and Planning: Number of farm families who developed whole farm plans to improve their farm financial performance.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	130

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management

Outcome #6

1. Outcome Measures

Tennessee Extension Leadership Development: Small businesses or non-profits developed by limited resource leaders.

2. Associated Institution Types

- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Limited resource leaders and small business owners or entrepreneurs have difficulty in securing information and training to start and operate a small business in Tennessee due limited resources, severe competition and lack of education or information to start or operate a successful small business.

What has been done
TSU Extension and TSU College of business through its entrepreneurship and small business development center provided educational programs to new and beginning small business owners and limited resource leaders to enhance their knowledge and skills in starting and operating a small business.

Results
Through the TSU Extension educational programs and workshops, three limited resource individuals were able to start a small business or participate in farmers markets successfully, with their new business knowledge and skills

4. Associated Knowledge Areas

KA Code	Knowledge Area
602	Business Management, Finance, and Taxation
608	Community Resource Planning and Development

Outcome #7

1. Outcome Measures

Assess the Local Food System/the Knoxville Foodshed (Hellwinckel)

Not Reporting on this Outcome Measure

Outcome #8

1. Outcome Measures

Promote the growth of the Tennessee viticulture industry by determining the impact of production designations (eco-labeling and other certifications) on consumer perception, preference and willingness to pay. (Kar)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
While the American Viticultural Areas (AVA) designation has been extensively utilized by wineries internationally and domestically, it is relatively underutilized in Tennessee. Despite its establishment in 1984, the wine production activities in this area remain largely underdeveloped. As a comparison, the Outer Coastal Plain AVA, established in 2007, has been credited to substantially increase the profile of wineries in New Jersey. This raises the question if similar success can be replicated in Tennessee, and other areas in the US where there exists the potential for growth in wine production.

What has been done
Preliminary econometric analyses were conducted, specifically, with a Willingness to Pay Space model.

Results
The Outer Coastal Plan AVA label generates a higher willingness to pay than the state appellation label (New Jersey, USA) and the sub AVA label (Pilesgrove, New Jersey). As all three could essentially be the same product, it suggests that consumers are confounded by the AVA

appellation label. While the AVA label holds promises as a marketing tool, more research is needed to investigate if consumers perceived the practice as fair and ethical.

4. Associated Knowledge Areas

KA Code	Knowledge Area
603	Market Economics

Outcome #9

1. Outcome Measures

Evaluate bioenergy economics (Yu, Jensen, Lambert, English)

Not Reporting on this Outcome Measure

Outcome #10

1. Outcome Measures

Advance the sustainability of small farm enterprises through assessment of income risks and the role of diversification strategies among small farms in Tennessee and the United States. (Khanal)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Small farms are unable to keep pace with agricultural advancements requiring high initial costs, so they carry uncertainty about future survival if they continue to follow conventional commodity production routes. For most small farms, the only way to stay in business is to diversify and increase their incomes, either through new alternatives on the farm or from off-farm employment by allocating production assets and resources among different on-farm and off-farm income-generating activities. Alternative agricultural enterprises such as agritourism, crop diversification, organic farming, conservation and their combinations could be viable on-farm diversification strategies.

What has been done

Using secondary data on national level, factors influencing diversification decisions among small farms were assessed. Using an appropriate econometric method, simultaneous decision making process in the adoption of agricultural-, structural-, environmental-, and income- diversification strategies were accounted for. To analyze the situation specific to Tennessee farmers, we conducted a primary survey; based on the response from the survey, we assessed diversification, crop and livestock enterprises adoption, financial constraints, challenges, and production risks among Tennessee farmers.

Results

We identified a set of diversification strategies such as income, environmental, agricultural, and structural among small farmers. A small farmer's decision model in diversification strategy choice was designed. We found the significant effects of demographic, socio-economic, and risk related factors affecting diversification decisions as well as the likelihood of credit constraint. Credit constraint has a significantly negative impact on financial performance. Factors such as age, education, use of smartphone with Internet access and level of risk concern have significant positive effects on the extent of debt financing while credit constraint, age, gender, marital status, household income, and risk perception have significant negative effects.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
602	Business Management, Finance, and Taxation

Outcome #11

1. Outcome Measures

Assessing Agricultural Entrepreneurship in Relation to Small Farmers (Tegegne)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Focus is on an important issue that affects the livelihood of small farmers and rural communities in which they are located. There are very few studies that examine the role of entrepreneurship in the operations of small farmers.

What has been done
Developed conceptual framework for the study. Secondary data search is complete. Obtained IRB approval to conduct the survey. Used Qualtrics to collected the data .

Results
Program has just begun, no results to report yet.

4. Associated Knowledge Areas

KA Code	Knowledge Area
603	Market Economics
604	Marketing and Distribution Practices

Outcome #12

1. Outcome Measures

Increase fruit and vegetable producers' understanding of factors that impact their marketing strategies and product pricing for direct-to-consumer outlets (Velandia)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Many farmers are considering new ways to market their produce such as farmers' markets, farm-to-school, and farm-to-institute programs, food hubs, and CSAs. A challenge faced by fruit and vegetable producers selling their produce at farmers markets is how to price their produce making sure they cover their cost of production and still make a profit. Small and medium-sized farms are those most likely to use farmers markets as a market outlet to sell their products, and the ones in greatest need of budget tools to better understand their production and marketing costs.

What has been done
Through field days and workshops we provided producers with tools and information aiming to help them identify market outlets that guarantee long-term sustainability of their farm businesses. Through train-the-trainer activities and presentations at professional conferences, we informed

Extension personnel and other researchers working with or producing information for fruit and vegetable producers about the factors influencing prices at farmers markets and how these factors could help producers set their produce prices at farmers markets.

Results
We generated a change in knowledge in Tennessee fruit and vegetable producers as they became aware of the factors they need to consider when selecting marketing strategies and pricing their products. Additionally, we made them aware of the factors they need to manage to guarantee the long-term sustainability of their farm business.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
603	Market Economics

Outcome #13

1. Outcome Measures

Increased understanding of producers' willingness to pay for increased biosecurity measures (Thompson)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Disease during animal production can create severe and lasting impacts on animal health, profitability, food safety, and food prices. Biosecurity practices can help limit disease exposure and reduce some of the negative impacts associated with a disease outbreak. Understanding producers' willingness to pay for biosecurity measures will provide important information to decision makers regarding biosecurity cost structures and policy.

What has been done
We used econometric analysis to analyze survey data of feedlot producers to estimate their willingness to preemptively invest in additional disposal capacity as a biosecurity measure. This would allow them better continuity of business during a highly infectious disease outbreak.

Results
Results show feedlot operators are willing to invest in approximately $14,000 in on-farm carcass disposal. This amount and willingness to invest differed by size of operation, the death loss-rate, and other managerial preference factors. The difference in operators speaks to the cash-flow abilities and cost-benefit proposition of investing in additional capacity.

4. Associated Knowledge Areas

KA Code	Knowledge Area
308	Improved Animal Products (Before Harvest)

Outcome #14

1. Outcome Measures

Improved understanding of potential for biofuels and associated feedstocks expansions (Jensen)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Pennycress, an oilseed plant with high oil content, is being considered as a second-generation biofuel feedstock. The plant's life cycle fits with traditional U.S. crop rotations. Economic studies are necessary to determine the economic feasibility and financial impact of pennycress as a biofuel feedstock.

What has been done
We examined the economic feasibility of pennycress production, its potential to supply a renewable aviation industry and its potential impacts on the U.S. economy.

Results
Incorporating pennycress in U.S. crop rotations at a price of $0.20 per pound stimulates 22.1 million acres of pennycress to be planted, and increases harvested acreage of corn and soybeans by 3.2 % and 5.0 %, respectively. To produce 800+ million gallons of jet fuel, 22 HEFA facilities fed by 43 oil extraction facilities are required resulting in the addition of $19 billion to the

nation's economy and nearly 66,000 jobs.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Limited resource businesses and landowners gained knowledge and skills necessary.

Key Items of Evaluation

1. Knowledge of Landownership and land transfer laws and regulations.
2. Knowledge and skill of owning and operating a small business in Tennessee.

V(A). Planned Program (Summary)

Program # 6

1. Name of the Planned Program

Environmental and Water Quality Impacts

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
101	Appraisal of Soil Resources	0%	0%	9%	0%
102	Soil, Plant, Water, Nutrient Relationships	20%	20%	17%	14%
111	Conservation and Efficient Use of Water	0%	0%	10%	0%
112	Watershed Protection and Management	80%	80%	36%	43%
132	Weather and Climate	0%	0%	2%	15%
133	Pollution Prevention and Mitigation	0%	0%	0%	14%
135	Aquatic and Terrestrial Wildlife	0%	0%	14%	14%
205	Plant Management Systems	0%	0%	4%	0%
403	Waste Disposal, Recycling, and Reuse	0%	0%	8%	0%
	Total	100%	100%	100%	100%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	5.0	1.0	35.0	12.0
Actual Paid	18.0	5.6	12.3	10.8
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
318324	163842	852371	324674
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1564271	246829	799326	460861
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	52098	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Environmental and water quality programs addressed issues that impact various aspects of the environment. Research, assessments, development of tools, and outreach activities included cover crops in soybean and cotton systems; stormwater management; climate variation and climate change impacts on onsite wastewater treatment systems and on crop yield and soil quality; water contamination from soil erosion and soil transport; the use of reclaimed water for agricultural production; flies as bioindicators of quality of streams where they occur; techniques to identify endangered species habitat and high stream bank erosion; soil viral diversity; and the behavior of antibiotics that enter the environment through animal manure applications.

Additionally, other activities include research to reduce the impact of pharmaceuticals and personal care products in surface water in rural and urbanizing watersheds, enhance biomass productivity of bioenergy feedstock on degraded lands, improve understanding of soil microbes and their long-term responses to climate warming, and research to influence change in understanding of proper management of riparian landscapes.

2. Brief description of the target audience

The target audience includes agricultural producers, environmental scientists, environmental regulatory agencies, greenhouse managers and horticulturalists, stormwater managers, and designers, practioners, and regulators of onsite wastewater treatment systems.

3. How was eXtension used?

.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	38498	868951	8522	15

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	2	25	27

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of arbuscular mycorrhizal fungi that enhance biomass productivity by cellulosic herbaceous perennials in fly ash-amended soils.
  Not reporting on this Output for this Annual Report

Output #2

Output Measure

- Leverage the Stormwater Management Center (Buchanan, Ludwig, Tyner, Yoder)
  Not reporting on this Output for this Annual Report

Output #3

Output Measure

- Relate community health and resilience to gas wells (Lambert)
  Not reporting on this Output for this Annual Report

Output #4

Output Measure

- Analyze long-term effects of disturbance on soil-dwelling organisms (Bernard)

Not reporting on this Output for this Annual Report

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Increased sustainable biomass production strategies by cellulosic herbaceous perennials in fly ash-amended soil to allow cleanup of toxic materials in the waste product while using the biomass as biofuel feedstock. (Dzantor)
2	Develop practical systems for organic forage production (Butler)
3	Help municipalities evaluate land use and development and related tax structures (Cho)
4	Optimize non-chemical methods of soil disinfestation (Butler)
5	Research to reduce the impact of pharmaceuticals and personal care products in surface water in rural and urbanizing watersheds. (Dennis)
6	Farmers and homeowners will be educated on the impact of pharmaceuticals and personal care products in surface water and the proper ways to dispose of these chemicals (Dennis)
7	Develop a greater understanding of the mechanisms of the studied emerging contaminants for the scientific community to expedite the decision making process in terms of protecting environmental health. (Rakshit)
8	Improve mechanistic understanding of microbial processing of soil decay and its long-term responses to climate warming. (J Li)
9	Research to influence change in understanding of proper management of riparian landscapes. (Sutton)
10	Use biodiversity of aquatic flies to assess environmental resilience (Moulton)
11	Couple chemical fingerprinting with microbial genetic markers for stream sediment source tracing (Essington)
12	Document the role of viruses in shaping soil bacterial community diversity and impacting biogeochemical cycling (Radosevich)
13	Evaluate how the surface retention of antibiotics on soil minerals can affect the retention / release of oxyanions of plant micronutrients. (Rakshit)
14	Extension Programming for Water Quality: Sustainable Residential Landscapes for Tennessee
15	Crop Nutrient Stewardship Impacts
16	Enhance biomass productivity of bioenergy feedstock on degraded lands through a greater understanding and mediation of soil microbial communities. (Dzantor)
17	Better understanding of plant uptake of trace organic chemicals from municipal biosolids used as crop amendments (Hawkins)

18	Increased understanding of climate variability/climate change impact on onsite wastewater treatment systems (Buchanan)
19	Increased understanding of best management practices to reduce soil erosion (Drumm)
20	Improve techniques for measuring effectiveness of stormwater control measures (Yoder)

Outcome #1

1. **Outcome Measures**

Increased sustainable biomass production strategies by cellulosic herbaceous perennials in fly ash-amended soil to allow cleanup of toxic materials in the waste product while using the biomass as biofuel feedstock. (Dzantor)

Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

Develop practical systems for organic forage production (Butler)

Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

Help municipalities evaluate land use and development and related tax structures (Cho)

Not Reporting on this Outcome Measure

Outcome #4

1. **Outcome Measures**

Optimize non-chemical methods of soil disinfestation (Butler)

Not Reporting on this Outcome Measure

Outcome #5

1. Outcome Measures

Research to reduce the impact of pharmaceuticals and personal care products in surface water in rural and urbanizing watersheds. (Dennis)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Incidence of pharmaceuticals in the environment is becoming a complex issue. Little is known about the potential health effects to humans or aquatic organisms exposed to the trace levels of these chemicals when present in water. Humans are primarily responsible for the pathway of pharmaceuticals to surface water, partly through excretion and disposal of unwanted medications to sewers and trash. Farm animals also contribute to some extent, through their excretion of veterinary medicines, and the use of animal manure as a soil amendment. Unfortunately, municipal wastewater treatment plants and septic systems are not engineered to remove these non-biodegradable products and non-metabolized drugs.

What has been done
Three rivers in Middle Tennessee were monitored during the summer of 2018. These rivers drained rural and urbanizing watersheds. Water samples were collected for the pharmaceuticals analysis for six consecutive weeks and analyzed for the concentration of non-steroidal anti-inflammatory drugs and heart treatment drugs, using GC/MS/MS. Farmers and homeowners were educated on the impact of pharmaceuticals in surface water and the proper ways to dispose of unused pharmaceuticals.

Results
The pharmaceuticals detected were non-steroidal anti-inflammatory drugs and heart treatment drugs. Specifically, the following pharmaceuticals were detected in all the three rivers monitored: atenolol, a heart treatment drug, the concentration ranged from 0.12- 0.78 parts per billion; clofibrate, a heart treatment drug, concentration ranged from 0.53-13.30 parts per billion; diclofenac, an anti-inflammatory drug, concentration ranged from 1.23- 3.57 parts per billion; ibuprofen, an anti-inflammatory drug, concentration ranged from 0.10- 1.47 parts per billion); metoprolol, a heart treatment drug concentration ranged from 1.32- 3.12 parts per billion; naproxen, an anti-inflammatory drug, concentration ranged from 0.52- 1.73 parts per billion; and

propranolol, a heart treatment drug concentration ranged from 0.04- 3.33 parts per billion.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management

Outcome #6

1. Outcome Measures

Farmers and homeowners will be educated on the impact of pharmaceuticals and personal care products in surface water and the proper ways to dispose of these chemicals (Dennis)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Low-level concentrations of pharmaceuticals have been detected in fresh water resources throughout the U.S. However, little is known about the potential health effects to humans or aquatic organisms exposed to the trace levels of these chemicals when present in surface water. As such there is a dire need of societal awareness on proper disposal of these chemicals especially among homeowners and apartment dwellers.

What has been done
Advancing efforts to mitigate this problem, consumers were made aware as well as led to understand how to ensure the safe disposal of pharmaceuticals. This was accomplished in the presentation of our results at the 2018 Emerging Contaminants in the Aquatic Environment conference in Champaign, IL. A special focus of the study is detailing the proper disposal of unused pharmaceuticals to avoid the incidence of these chemicals in surface water. The project was engaged in a drug take back event held in Nashville Tennessee, in 2018.

Results
The drug take back program was a means of disposing of unused Rx drugs by consumers. The impact of the drug take back, is far reaching and goes beyond the targeted stakeholders (homeowners and apartment residence life). As a result our mitigating effort has enhanced the reduction of the quantities of Rx drugs entering middle Tennessee waterways (surface water) as

well as the drugs being stockpiled in homes awaiting misuse or abuse.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management

Outcome #7

1. Outcome Measures

Develop a greater understanding of the mechanisms of the studied emerging contaminants for the scientific community to expedite the decision making process in terms of protecting environmental health. (Rakshit)

Not Reporting on this Outcome Measure

Outcome #8

1. Outcome Measures

Improve mechanistic understanding of microbial processing of soil decay and its long-term responses to climate warming. (J Li)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Soil harbors the largest organic C pool in the terrestrial biosphere, with more than 1500 Gt in the top meter globally. Annual soil CO2 efflux is about six times of that from fossil fuel burning. Microbial communities are the primary drivers of soil organic carbon mineralization and respiratory C loss to atmosphere. Global soil carbon stocks are expected to decline with warming, and changes in microbial processes are key to this projection. However, warming responses of critical microbial parameters such as carbon use efficiency and biomass turnover are not well understood. Because both climate warming and nitrogen fertilization can accelerate soil CO2 efflux to the atmosphere, investigation of microbial transformation of soil organic carbon under both climate warming and nitrogen fertilization becomes a research priority.

What has been done
Data synthesis was conducted to examine how extracellular enzymes influence soil CO2 emission under climate warming and N fertilization.
A model and 22-year long datasets were fused to achieve the best key microbial parameters and used for improving long-term soil projection under climate warming. Geostatistical analyses were conducted to examine impact of N fertilization elevated on spatial distribution of microbes in soil. A new soil sampling method was developed.

Results
Results showed that climate warming enhanced ligninase activity (i.e., agents for lignin decomposition) and thus resulted in greater soil CO2 emission, and no such relationship was found for cellulase and emission. On the other hand, warming increased soil CO2 emission by altering the microbial community physiology, i.e., lowering growth efficiency. Data-model fusion results however showed no physiological adaptation to long-term warming. N fertilization increased soil CO2 emission by stimulated cellulase (i.e., agents for cellulose decomposition). A simple, efficient and clustered sampling procedure was developed to promote the experimental rigor in soil sampling.

4. Associated Knowledge Areas

KA Code	Knowledge Area
132	Weather and Climate

Outcome #9

1. Outcome Measures

Research to influence change in understanding of proper management of riparian landscapes. (Sutton)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
A variety of land uses, including urbanization, mining, and agriculture, threaten the quality of water resources throughout Tennessee. Land mitigation via restoration represents a viable option for conservation of landscapes and water quality. However, riparian areas represent habitats that

tend to be overlooked and are difficult to restore once they are degraded. Many stream-dwelling organisms, including the eastern hellbender (Cryptobranchus alleganiensis) can be used as biological indicators to gauge the quality of water body along with effectiveness of restoration efforts. Often, conservation efforts need to consider multiple spatial scales for effective management and conservation of rare and sensitive species.

What has been done

We have collaborated with state-level organizations to acquire and develop an extensive occurrence database for the Eastern Hellbender (Cryptobranchus alleganiensis) throughout Tennessee. These occurrences have been used to develop a preliminary habitat model for the state. Based on the habitat model over 300 sites have been sampled throughout TN for C. alleganiensis presence. In addition to the original habitat suitability model, we have evaluated site occupancy of C. alleganiensis and have accounted for errors in detection among seasonal-repeated sample sites.

Results

Results indicate that optimal aquatic habitats for Eastern Hellbenders appear to be those not yet impacted by agricultural and forestry practices, suggesting that greater measures must be taken to make anthropogenic land- uses more compatible with biodiversity conservation. A preliminary habitat model is being evaluated and data from the eDNA analysis has led to a C. alleganiensis landscape occupancy model. Results indicate current and historical landuse practices are important for determining optimal C. alleganiensis locations. These results are relevant at the ecoregion scale and show the Blue Ridge ecoregion has greatest occupancy, which we attribute to forest preservation and conservation efforts. Other ecoregions have been highly impacted by forestry and agricultural operations, which have impaired adjacent watersheds. In addition to our landscape model efforts, we have found that microhabitat requirements are different for adult, juvenile, and larval C. alleganiensis.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
135	Aquatic and Terrestrial Wildlife

Outcome #10

1. Outcome Measures

Use biodiversity of aquatic flies to assess environmental resilience (Moulton)

Not Reporting on this Outcome Measure

Outcome #11

1. **Outcome Measures**

Couple chemical fingerprinting with microbial genetic markers for stream sediment source tracing (Essington)

Not Reporting on this Outcome Measure

Outcome #12

1. **Outcome Measures**

Document the role of viruses in shaping soil bacterial community diversity and impacting biogeochemical cycling (Radosevich)

Not Reporting on this Outcome Measure

Outcome #13

1. **Outcome Measures**

Evaluate how the surface retention of antibiotics on soil minerals can affect the retention / release of oxyanions of plant micronutrients. (Rakshit)

2. **Associated Institution Types**

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The results from this project will be useful to environmental scientists, agronomists, environmental toxicologists or other scientists who would want to evaluate the influence of the elevated antibiotics on nutrient cycling.

What has been done
Competitive surface interaction mechanisms of Mo and oxytetracycline antibiotics on iron oxide mineral hematite had been evaluated using macroscopic and spectroscopic experiments.

Results
Molybdenum (Mo) retention on hematite indicated a pH-dependence, in which more Mo retained on hematite surface at acidic pH values. Antibiotic oxytetracycline did not affect Mo retention in acidic pH values; however, some effect was noticed at higher pH values. Spectroscopic data confirmed these findings.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
133	Pollution Prevention and Mitigation

Outcome #14

1. Outcome Measures

Extension Programming for Water Quality: Sustainable Residential Landscapes for Tennessee

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Residential landscapes also impact Tennessee's natural capital. Over 12% of Tennessee lands are developed for urban and suburban uses which are linked to water quality degradation, soil quality degradation, and impacts to outdoor recreation and fisheries. Since 2004, there has been a 36% increase in stream impairments due to urbanization. Tennesseans need information on sustainable landscaping practices in order to maintain high property values and sustainability of natural capital in communities.

What has been done
In 2018, 15,050 residents received information about sustainable cultural practices and recommendations on conservation and environmental stewardship.

Results

As a result of the sustainable residential landscaping program in 2018:
-2258 residents implemented conservation landscape practices
-2221 residential landscapes/yards have been improved by sustainable landscaping practices
-1473 residents implemented sustainable stewardship practices

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management

Outcome #15

1. Outcome Measures

Crop Nutrient Stewardship Impacts

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
With low crop prices, increasing prices of nitrogen and phosphorous 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. Increasing the use of sustainable resource management practices will enable the world to meet present needs while continuously improving future generation's ability to meet their own needs. This can be done not only by lessening our environmental impacts, improving human health, and improving the economic and social well-being of Tennessee's communities, but also by increasing productivity to meet current as well as future food, fuel, and fiber demands.

What has been done
An integrated, multi-disciplinary research, education, and outreach program has been established to develop and disseminate information pertaining to crop fertility practices and associated economic and environmental impacts. We 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.

Results

Our Crop Nutrient Stewardship educational efforts in 2018 resulted in the following impacts:
-1070 producers assessed nutrient needs by conducting soil sampling on approximately 395,000 acres potentially reducing fertilizer costs by $16.20/acre and 7,100 tons of excess phosphorous from potentially moving offsite and causing environmental degradation.
-712 producers utilized UT fertility recommendations on approximately 140,000 acres resulting in a potential reduction of phosphorous pentoxide fertilizer costs of $14.70/acre as well as more than 15,000 tons of phosphorous pentoxide fertilizer that could move offsite and have negative environmental consequences

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships

Outcome #16

1. Outcome Measures

Enhance biomass productivity of bioenergy feedstock on degraded lands through a greater understanding and mediation of soil microbial communities. (Dzantor)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Bioenergy has been promoted as one solution to modulate the three-pronged environmental, energy and food challenges that the world faces today. However, bioenergy production is limited by suitable arable land to produce food, feed, fiber as well as bioenergy. Recent findings suggest that marginal, degraded, abandoned, contaminated or otherwise unproductive lands can be used for biofuel feedstock production to meet much of current world fuel consumption without affecting food and forage production. The challenges are how to produce biomass feedstock sustainably on problem land and how much biomass can such lands actually produce?

What has been done

Using two problem soils from Tennessee, a series of greenhouse experiments to identify cropping systems (treatments) that enhanced abilities of soil microbial communities to increase biomass production of switchgrass, the model bioenergy feedstock. Switchgrass was grown in small containers under several treatments. Subsequently, five treatments were selected for further investigation in large greenhouse pots. They included i) soil inoculation with propriety microbial preparation containing mycorrhiza (BioVam); ii) soil amendment with organic substrates (paper mill sludge or vermicompost) or inorganic nitrogen (urea); 3) combinations of soil inoculation and amendment.

Results

To date, three harvests have been conducted to determine switchgrass yield and composition as well as soil microbial communities under the various treatments. Data analysis is underway. Results from greenhouse observations will guide the field-level confirmations required prior to making definitive recommendations to stakeholders.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
205	Plant Management Systems
403	Waste Disposal, Recycling, and Reuse

Outcome #17

1. Outcome Measures

Better understanding of plant uptake of trace organic chemicals from municipal biosolids used as crop amendments (Hawkins)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The land application of municipal biosolids (a stabilized by-product of wastewater treatment plants) for crop production is an attractive disposal option for the public at large, when considering cost. There are just concerns about the potential for plant uptake of heavy metals and trace organic chemicals (TOrCs) that are present in biosolids (i.e., copper, zinc, pharmaceuticals, and personal care products). Further research is needed about the plant uptake of heavy metals and trace organic chemicals from biosolids and possible impacts on food safety.

What has been done
Replicated plot and greenhouse yield studies were used for corn and/or fescue grown using biosoilds as a soil amendment. Archived (frozen) samples of corn grain and fescue forage were analyzed for TOrCs.

Results
Limited uptake to corn grain of Metformin, Digoxigenin, and Ofloxacin was detected. Limited uptake to fescue forage of Erythromycin, Penicillin, Sufladazine, Sulfathiazole, Caffeine, Carbamazepine, Diphenhydramine, and Ofloxacin was detected.

4. Associated Knowledge Areas

KA Code	Knowledge Area
403	Waste Disposal, Recycling, and Reuse

Outcome #18

1. Outcome Measures

Increased understanding of climate variability/climate change impact on onsite wastewater treatment systems (Buchanan)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
With sea level rise and increased precipitation, climate change is expected to reduce the depth of unsaturated soil in many parts of the world. Onsite wastewater treatment systems that use the soil for aerobic treatment depend on this thin layer of soil. The use of subsurface drip distribution is a means of using the reduced soil depth to its maximum renovation potential, yet saturated

situations still can occur. The ability to predict and quantify when saturated conditions will occur will enable engineers to design drip dispersal systems and protect shallow groundwater.

What has been done
We examined relationships between soil properties, climate variables and movement of water in the STA and underlying vadose zone.

Results
The primary cause for saturated soil conditions in drip dispersal systems is the effluent remaining in the tubing at the end of a dose cycle. I have developed a model to help engineers account for this additional water in their system designs. This new information will help engineers design drip dispersal systems that do a better job of minimizing soil saturation to protect shallow groundwater resources, and will impact how regulators perform their inspections.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water

Outcome #19

1. Outcome Measures

Increased understanding of best management practices to reduce soil erosion (Drumm)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Best management practices (BMP's) reduce soil erosion and subsequent transport of soil in the surface waters. BMP's have not addressed highly disturbed or anthropogenic soils (land or mine reclamation, slope construction, etc.) particularly with steep slopes and soil that lacks nutrients. With the development of BMP's which include strategic choices of the shape of the ground surface (landforming or geomorphic reclamation), erosion can be reduced leading to the more rapid establishment of ground cover and minimization of sediment transport, while producing landscapes that appear more natural, and are sustainable and productive.

What has been done
The RUSLE2 routines were used to calculate soil loss, and the effects of climate and landform was implemented using algorithms developed in the Matlab platform.

Results
In this study, concave profiles in rainfall erosion equilibrium were found based on the principles of the well-known RUSLE2 model. Results show the existence of a family of steady shapes satisfying the condition of uniform erosion rate. Those steady concave shapes that also satisfy long-term mechanical stability were then investigated. The overall results suggest that concave slopes can be constructed to achieve both minimal steady-state erosion equilibrium and mechanical stability, leading to more "natural" and sustainable landforms with minimal sediment delivery during initial slope adjustments.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management

Outcome #20

1. Outcome Measures

Improve techniques for measuring effectiveness of stormwater control measures (Yoder)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Stormwater Control Measures (SCMs) are used to control erosion and sediment delivery from disturbed lands and excessive runoff and contaminant wash-off from urban areas. It is difficult yet critical to measure the effectiveness of SCMs within a specific design, and to select the best SCMs for a specific site. Researchers must develop devices and techniques to provide better measurement of SCM effectiveness to allow for optimized selection and design site-specific SCMs. Ultimately, this will result in reduced impacts of excessive runoff and contaminant transport into rivers and streams.

What has been done
We developed and tested a second-generation prototype device to accurately and repeatedly measure sediment in runoff samples.

Results
We developed and tested a 2nd-generation of a prototype device to measure the sediment mass in a stormwater sample in-situ and in near real time. A first-generation prototype was built and tested, and provided accurate and repeatable measurement of sediment concentrations ranging from 100 - 125,000 ppm.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Public Policy changes
- Competing Public priorities

Brief Explanation

{No Data Entered}

V(I). Planned Program (Evaluation Studies)

Evaluation Results

• Research to determine the prevalence of pharmaceutical drugs in rivers and streams, and education of the pubic on the importance of proper disposal of pharmaceutical drugs.
• A simple, efficient and clustered sampling procedure was developed to promote the experimental rigor in soil sampling to measure the effects of fertilization practices in global warming.
• Research to identify watersheds that are still of good quality and watersheds that are in need of restoration and further restoration and protection to maintain and/or improve water quality. Increased knowledge of likely habitats for aquatic species of special conservation concern.

Key Items of Evaluation

V(A). Planned Program (Summary)

Program # 7

1. Name of the Planned Program

Family Economics

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
801	Individual and Family Resource Management	100%	100%	0%	0%
	Total	100%	100%	0%	0%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	12.0	2.0	0.0	0.0
Actual Paid	9.0	2.0	0.0	0.0
Actual Volunteer	7.3	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
198952	61866	0	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
977670	93307	0	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
291255	19672	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Financial education activities were conducted through bankruptcy education, homebuyer education, High School Financial Planning and teacher training, savings education for adults and youth, and financial

simulations for youth. This included group trainings and programs and exhibits.

2. Brief description of the target audience

Youth and adults were targeted for this program. UT Extension is a national leader in creating, testing and validating family economic programs for reaching different target audiences, such as youth ages 9-18, young adults, coalition members and consumers.

3. How was eXtension used?

Extension professionals were members of the Financial Security eXtension Community of Practice in 2018.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	49110	8522861	52423	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	0	0	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of exhibits displayed to promote program awareness and participation.

Year	Actual
2018	170

Output #2

Output Measure

- Number of research-based publications distributed as part of this program.

Year	Actual
2018	30407

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	TN Saves: Number of participants who estimated their retirement income needs.
2	TN Saves: Number of participants identified ways to reduce debt.
3	TN Saves: Number of participants who set financial or retirement goals.
4	Youth Financial Education Simulation: Number of participants who felt more strongly that they needed to get a good education.
5	TN Saves: Number of participants who followed a spending plan.
6	TN Saves: Number of participants who initiated or increased savings.
7	TN Saves: Number of participants who reduced debt.
8	TN Saves: Statewide economic impact from reduced debt, increased savings and increased investment. (This outcome target is expressed in millions of dollars.)

Outcome #1

1. **Outcome Measures**

TN Saves: Number of participants who estimated their retirement income needs.

Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

TN Saves: Number of participants identified ways to reduce debt.

Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

TN Saves: Number of participants who set financial or retirement goals.

2. **Associated Institution Types**

- 1862 Extension
- 1890 Extension

3a. **Outcome Type:**

Change in Knowledge Outcome Measure

3b. **Quantitative Outcome**

Year	Actual
2018	3298

3c. **Qualitative Outcome or Impact Statement**

Issue (Who cares and Why)

What has been done

Results

4. **Associated Knowledge Areas**

KA Code	Knowledge Area
801	Individual and Family Resource Management

Outcome #4

1. Outcome Measures

Youth Financial Education Simulation: Number of participants who felt more strongly that they needed to get a good education.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	10654

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
801	Individual and Family Resource Management

Outcome #5

1. Outcome Measures

TN Saves: Number of participants who followed a spending plan.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1414

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
801	Individual and Family Resource Management

Outcome #6

1. Outcome Measures

TN Saves: Number of participants who initiated or increased savings.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1122

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
801	Individual and Family Resource Management

Outcome #7

1. Outcome Measures

TN Saves: Number of participants who reduced debt.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	220

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
801	Individual and Family Resource Management

Outcome #8

1. Outcome Measures

TN Saves: Statewide economic impact from reduced debt, increased savings and increased investment. (This outcome target is expressed in millions of dollars.)

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1792200

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
801	Individual and Family Resource Management

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Competing Public priorities
- Competing Programmatic Challenges

Brief Explanation

{No Data Entered}

V(I). Planned Program (Evaluation Studies)

Evaluation Results

UT and TSU educational programs increased awareness among adults and youth in Tennessee about the importance of personal finances. The estimated economic impact of participants' saving totaled $1,186,683 in 2018 with debt reduction estimates totaling $605,517. The total estimated impact of Extension Tennessee Saves adult and youth programs and the youth financial simulations was $1.8 million dollars in increased savings and reduced debt.

Key Items of Evaluation

The total estimated impact of Extension Tennessee Saves adult and youth programs and the youth financial simulations was $1.8 million dollars in increased savings and reduced debt.

V(A). Planned Program (Summary)

Program # 8

1. Name of the Planned Program

Food Safety

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms	0%	0%	5%	0%
204	Plant Product Quality and Utility (Preharvest)	0%	0%	5%	0%
212	Diseases and Nematodes Affecting Plants	0%	0%	19%	0%
501	New and Improved Food Processing Technologies	0%	0%	10%	33%
502	New and Improved Food Products	0%	0%	21%	17%
503	Quality Maintenance in Storing and Marketing Food Products	10%	10%	7%	0%
504	Home and Commercial Food Service	10%	10%	0%	0%
511	New and Improved Non-Food Products and Processes	0%	0%	14%	0%
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins	40%	40%	19%	50%
903	Communication, Education, and Information Delivery	40%	40%	0%	0%
	Total	100%	100%	100%	100%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	9.0	1.0	35.0	8.0
Actual Paid	13.5	1.0	8.8	8.5
Actual Volunteer	1.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
238743	30910	552772	255530
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1173203	46618	594980	362714
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
118442	9828	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

In the Safe Food for Tennessee initiative, UT and TSU Extension taught lessons in homes, schools, community centers, churches, and other accessible locations to consumers. The lessons in "Cook's Corner" and "Safe Food for You" are designed to change attitudes, skills and behaviors in regards to safe food handling practices.

Youth participants received food safety education using Fight BAC and other curricula through their school classroom, community center, after-school program, or other locations to reach youth. Direct methods (group meetings, classes, demonstrations, and on-site visits) and indirect methods (newsletters, TV media programs, web sites, newspaper articles and radio programs) emphasize safe food practices:

- using a thermometer to check the internal temperature of food.
- using a thermometer to check the internal temperature of the refrigerator.

We conducted applied and basic research in food-borne risks and nutrition to address high priority issues for consumers of food products. We disseminated information gained from these studies to food industries and consumers through outreach programs, including workshops and educational events at the county level, and through a variety of publications.

Surveys were conducted to evaluate the impact of natural antimicrobials on perceived sensory characteristics of food products. Lab experiments led to a better understanding of the role of biopolymer ingredients on the quality and safety of frozen foods. Research experiments and risk analyses were conducted to prevent and mitigate food safety risk during production and processing. Researchers developed a novel tool for chloroplast biotechnology.

Research will also characterize, analyze, and identify pathogenic profiles and patterns of pathogenic microorganisms in fresh produce and farm environments and deliver educational programs to producers and consumers on hygienic agricultural and food handling practices that are needed to improve fresh produce safety. In addition, the program will reduce antibiotic-resistant bacteria in fresh produce and the farm environment; change the behaviors of consumers and farmers to produce safer fresh produce handling practices and judicious use of antibiotics; and train competitive students with relevant skills for employment opportunities in food safety. Also the development of biosensor methods for rapid detection of Salmonella on leafy vegetables. This is crucial for producers, processors, and food testing laboratories seeking new technologies to ensure the safety of the food products, especially raw vegetables. Research to develop new methods to identify and reduce contaminants in the food supply, namely food science research to develop new methods to reduce toxins in milk that are resistant to normal pasteurization techniques.

2. Brief description of the target audience

- Consumers
- Employees of Child Care Centers
- SNAP and WIC clients

- Food producers

3. How was eXtension used?

Tennessee Extension professionals were members of Food Safety Community of Practice answered food safety questions for eXtension programs.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	228398	1666044	3625	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

62/737383 (9/28/2018) Discovery of Soybean Cyst Nematode Resistance Genes Based on Epigenetic Analysis

60731445 (9/14/2018) Inhibiting Ice Recrystallization by Nanocelluloses

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	0	25	25

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of exhibits displayed to promote safe food handling practices.

Year	Actual
2018	17

Output #2

Output Measure

- Number of research-based publications distributed by Extension to educate producers, processors, and consumers.

Year	Actual
2018	8250

Output #3

Output Measure

- Control A. acidoterrestris bacterium in pasteurized fruit juices (Golden)
  Not reporting on this Output for this Annual Report

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Safe Food Handling for Consumers: Number of consumers who more often washed their hands with soap and warm running water before preparing food.
2	Safe Food Handling for Consumers: Number of consumers who now separate raw, cooked, and ready-to-eat foods while storing and preparing.
3	Safe Food Handling for Consumers: Number of consumers who now use a thermometer to check the internal temperature of food.
4	Safe Food Handling for Consumers: Number of consumers who canned vegetables following a tested recipe.
5	Inactivate viral pathogens (D'Souza, Davidson)
6	Prevent, rather than responding to, food-borne illness (Buchanan, Critzer, Wszelaki, Lockwood)
7	Target leading foodborne human pathogen C. jejuni (Lin)
8	Research to develop an Immunochemical Fingerprint Analysis method to be specific and sensitive and applicable as a diagnostic assay to identify and differentiate Salmonella isolates from various sources of food contamination. (Chen)
9	Research to develop process innovations and innovative manufacturing technologies providing high quality, novel or modified, healthy products with improved safety profiles using state-of-the-art optical technologies for aflatoxin removal from foods. (Patras)
10	Investigate cell cytotoxicity, cell viability and cytokine analysis using murine macrophage cell line to assess the activity of treated aflatoxins. (Patras)
11	Research to provide logical corridors to mitigate antibiotic-resistance in the Tennessee food system. (Kilonzo Nthenge)
12	Development of science based information on judicious use of antibiotics for agricultural commodity producers. (Kilonzo Nthenge)
13	Produce gluten-free food ingredient from sorghum proteins (Dia)
14	Research to develop and validate a novel concentration method for the rapid, low-cost, and efficient isolation of Salmonella from foods, and to develop and validate an automated biosensor method for the detection of Salmonella (Chen)
15	Advanced descriptive sensory methods and techniques for better understanding of the sensory profile of processed liquid foods. (Ravi)
16	Increased awareness of food contamination risk during food production (D'Souza)
17	Increased understanding of the effect of freezing-thawing induced biopolymer interactions (Wu)

18	Development of novel tools to enable the engineering of novel nanomaterials in plants (Lenaghan)

Outcome #1

1. Outcome Measures

Safe Food Handling for Consumers: Number of consumers who more often washed their hands with soap and warm running water before preparing food.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	7392

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
504	Home and Commercial Food Service
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins

Outcome #2

1. Outcome Measures

Safe Food Handling for Consumers: Number of consumers who now separate raw, cooked, and ready-to-eat foods while storing and preparing.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	52

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
504	Home and Commercial Food Service
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins

Outcome #3

1. Outcome Measures

Safe Food Handling for Consumers: Number of consumers who now use a thermometer to check the internal temperature of food.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual

2018	47

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
503	Quality Maintenance in Storing and Marketing Food Products
504	Home and Commercial Food Service

Outcome #4

1. Outcome Measures

Safe Food Handling for Consumers: Number of consumers who canned vegetables following a tested recipe.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	644

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area

503	Quality Maintenance in Storing and Marketing Food Products
504	Home and Commercial Food Service
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins

Outcome #5

1. **Outcome Measures**

Inactivate viral pathogens (D'Souza, Davidson)

Not Reporting on this Outcome Measure

Outcome #6

1. **Outcome Measures**

Prevent, rather than responding to, food-borne illness (Buchanan, Critzer, Wszelaki, Lockwood)

Not Reporting on this Outcome Measure

Outcome #7

1. **Outcome Measures**

Target leading foodborne human pathogen C. jejuni (Lin)

Not Reporting on this Outcome Measure

Outcome #8

1. **Outcome Measures**

Research to develop an Immunochemical Fingerprint Analysis method to be specific and sensitive and applicable as a diagnostic assay to identify and differentiate Salmonella isolates from various sources of food contamination. (Chen)

Not Reporting on this Outcome Measure

Outcome #9

1. **Outcome Measures**

Research to develop process innovations and innovative manufacturing technologies providing high quality, novel or modified, healthy products with improved safety profiles using state-of-the-art optical technologies for aflatoxin removal from foods. (Patras)

2. **Associated Institution Types**

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Mycotoxins are fungal metabolites commonly occurring in food, which pose a health risk (i.e. cancer) to the consumer and public in general. Aflatoxins are a group of potent mycotoxins with mutagenic, carcinogenic, teratogenic, hepatotoxic, and immunosuppressive properties and are of significance due to their occurrence and adversative effects on animal and human health. Maximum levels for major mycotoxins allowed in food have been established worldwide. But still, persistence of mycotoxins or their metabolites is a major safety concern world-wide especially in developing countries. The persistence of aflatoxins (AFB1, AFG1, AFB2 and AFG2), patulin and their metabolites in agricultural products is a major safety concern due to their high resistance to current methods.

What has been done
Efficacy of a low pressure lamp to reduce aflatoxins (AFB1) in milk was investigated. Optical properties of the milk was calculated using a computer model. Experiments were conducted using a collimated beam system operating between at 254 nm wave-length. The concentration of AFB1 was reduced by 4.08%, 8.58%, 10.21% and 22.47% with UV doses 100, 200, 300 and 400 mJ/cm2 respectively. It can be inferred that this trend may yield better reduction values when experimented with higher doses

Results
UV irradiation significantly reduced aflatoxins milk. Irradiation doses up to 0-400 mJ.cm-2 reduced AFB1 content by 22.47% in milk (a highly opaque fluid). All delivered doses were verified using MS2 bacteriophage (positive-sense single-stranded RNA virus).

4. Associated Knowledge Areas

KA Code	Knowledge Area
501	New and Improved Food Processing Technologies

Outcome #10

1. Outcome Measures

Investigate cell cytotoxicity, cell viability and cytokine analysis using murine macrophage cell line to assess the activity of treated aflatoxins. (Patras)

Not Reporting on this Outcome Measure

Outcome #11

1. Outcome Measures

Research to provide logical corridors to mitigate antibiotic-resistance in the Tennessee food system. (Kilonzo Nthenge)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Foodborne pathogens and their toxins cause foodborne diseases. The Centers for Disease Control (CDC) reported 902 foodborne diseases occurrences that resulted to 15,202 infections, 950 hospitalizations, and 15 mortalities in 2015. Pathogenic bacteria have developed resistance to antibiotics causing a great threat to their application in human medicine. Antimicrobial resistant bacteria from food animals is transmitted to humans through foodborne pathogens whose reservoirs are food animals including cattle and poultry. Antimicrobial resistance is considered as a concern both in agriculture and public health.

What has been done
Farms were visited and environmental samples including soil, manure (cattle, poultry), and water were collected. Research was conducted to determine antimicrobial resistant bacteria from different niches in poultry and cattle production systems. Biochemical tests, standard methods, Polymerase Chain Reaction, and metagenomics were used for microbial analysis.

Results
Analyses indicated the predominant bacterial phylum isolated in soil, water, and animal feces was Firmicutes. There were 155 distinct antibiotic resistant gene types, which conferred resistance to

31 different antimicrobials. The most abundant genes were classified under aminoglycoside and tetracycline resistance genes, followed by Beta-lactam-resistance, and Macrolide resistant. A total of 147 virulence genes in 32 different bacteria species were identified in feces, soil, and water samples in all farms.

4. Associated Knowledge Areas

KA Code	Knowledge Area
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins

Outcome #12

1. Outcome Measures

Development of science based information on judicious use of antibiotics for agricultural commodity producers. (Kilonzo Nthenge)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Antimicrobial resistance phenotypic data can be used to understand the antibiotic resistant gene spreading between and among microbial communities in farming production systems. Antimicrobial resistance data can be used to train farmers and future workforce on ways of limiting the spread of pathogenic and resistant bacteria from the environment to animals, food, and potentially to humans.

What has been done
Workshops were conducted to educate animal producers, students, and extension agents on Best Management Practices and record keeping on the usage of antibiotics on farms. Not all animal producers engaged with veterinarians for advice. Through research in the Food Microbiology laboratory at Tennessee State University, students were also trained through experiential learning on characterization of antibiotic resistant bacteria isolated from cattle and poultry farms.

Results

According to stakeholder feedback, a significant percentage of animal producers did not regularly engage with veterinarians. Antimicrobial stewardship education and engagement of veterinarians and farmers is important towards mitigation of antibiotic resistance in animal production systems. Students were trained and positioned to contribute towards mitigation of antimicrobial resistance in food systems.

4. Associated Knowledge Areas

KA Code	Knowledge Area
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins

Outcome #13

1. Outcome Measures

Produce gluten-free food ingredient from sorghum proteins (Dia)

Not Reporting on this Outcome Measure

Outcome #14

1. Outcome Measures

Research to develop and validate a novel concentration method for the rapid, low-cost, and efficient isolation of Salmonella from foods, and to develop and validate an automated biosensor method for the detection of Salmonella (Chen)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Salmonella is one of the most important foodborne pathogens. Every year, Salmonella is estimated to cause one million illnesses in the United States. To reduce the incidence of illnesses caused by Salmonella, advanced detection technology is needed to provide reliable and efficient identification of Salmonella from contaminated foods.

What has been done
This project has developed a SPR biosensor method in conjunction with the Immunomeganetic Separation for detection of low levels of Salmonella in leafy vegetables. Samples of romaine lettuce were inoculated with Salmonella typhimurium at low levels and incubated overnight. The numbers of naturally occurring bacteria and the inoculated Salmonella in the samples before and after incubation were determined. Salmonella flagellin antigen was captured on magnetic beads and injected onto the SPR sensor.

Results
The results suggest that the SPR biosensor can be used for rapid detection of Salmonella typhimurium in leafy vegetables with higher specificity and sensitivity. The IMS isolated samples yielded an average detection signal of 22.9 ± 5.5 microRIU, whereas the average detection signal for non-isolated samples was 4.1 ± 0.4 microRIU. The biosensor detection sensitivity was 2.4×105 CFU/mL after enrichment. The lowest detection limit in inoculated samples before enrichment was 80 CFU/g.

4. Associated Knowledge Areas

KA Code	Knowledge Area
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins

Outcome #15

1. Outcome Measures

Advanced descriptive sensory methods and techniques for better understanding of the sensory profile of processed liquid foods. (Ravi)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Consumer preference and acceptability is of primary importance and maintaining quality is of major concern in the food industry. Monitoring sensory quality attributes of liquid foods/beverage has been gaining importance and recognition in food processing.

What has been done

Quantitative Descriptive Analysis was performed on control and UV-treated Cranberry Flavored Water samples on a 15cm length descriptive scale. UVC-treated or non-treated control samples (20mL) were offered in 50mL disposable cups with lids, coded with random three-digit numbers. The samples were presented in randomized manner in order to avoid first-order and carry-over effects.

Results
Statistical analysis revealed that except burnt note, all other tested attributes of Cranberry Flavored Water had no significant difference among control, 30 and 120 mJ/cm2 treated samples.

4. Associated Knowledge Areas

KA Code	Knowledge Area
501	New and Improved Food Processing Technologies
502	New and Improved Food Products

Outcome #16

1. Outcome Measures

Increased awareness of food contamination risk during food production (D'Souza)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Rainwater catchment systems serve to lower irrigation costs and support sustainable agricultural initiatives. Contaminated irrigation sources can be a significant source of foodborne pathogens. Monitoring the presence of pathogens within the water source is key for determining the viability of this irrigation method.

What has been done
At an agricultural production site, water samples were collected and analyzed from three rainwater catchment tanks which supply irrigation water to three respective drip irrigation systems

within high tunnels.

Results
Coliform bacteria, generic E. coli, and STEC were detected in the rainwater catchment system studied over the course of a year. This indicates there is potential for produce contamination and mitigation strategies should be implemented with these systems. A weak correlation was also observed between STEC and both indicator organisms, demonstrating a linkage for routine water testing. This study informed the agricultural producers of potential food safety risks with their irrigation systems.

4. Associated Knowledge Areas

KA Code	Knowledge Area
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins

Outcome #17

1. Outcome Measures

Increased understanding of the effect of freezing-thawing induced biopolymer interactions (Wu)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The sale of frozen foods in the U.S. has stalled industry wide since 2013. Frozen foods are easily associated with quality problems such as 1) texture deficiency, 2) moisture migration within product, or 3) drip loss on thawing all due to the formation and growth of ice crystals. Problems like these have a negative impact on general consumer acceptance. Frozen foods manufacturers must develop innovative products of highest quality to attract more consumers and remain competitive in the food marketplace.

What has been done
We studied the effect of alginate cryogelation on the freeze-thaw (FT) stability of emulsions. In the

absence of alginate, emulsions stabilized with Tween 20 and sugar esters were not stable against FT treatment. In the presence of alginate, improved stability of emulsions, i.e. less oiling-off was observed after FT treatment at pH 5.0 where cryogelation was not occurred. However, significant improved stability, i.e. complete retarding of creaming, no oiling-off, and smaller emulsion droplet sizes were observed at pH 3.5 and 3.0 where cryogelation was occurred. The improved FT stability was associated with the increased emulsions moduli due to cryogelation.

Results
Our results indicated that cryogelation of biopolymers could be used to improve the freeze-thaw stability of emulsions.

4. Associated Knowledge Areas

KA Code	Knowledge Area
502	New and Improved Food Products

Outcome #18

1. Outcome Measures

Development of novel tools to enable the engineering of novel nanomaterials in plants (Lenaghan)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Chloroplast biotechnology allows researchers to develop plants with preferred traits. The cost of this technology may prohibit researchers with limited resources from engaging in this work. There is a need for chloroplast biotechnology tools that are not cost-prohibitive.

What has been done
We developed and validated the Modular Chloroplast Transformation Toolbox (MoChlo) to enable facile chloroplast engineering in a variety of species, including corn, tobacco, and potato. Experiments were conducted using the toolkit to install a variety of cassettes for the formation of novel porteinaceous nanocompartment in the chloroplast of tobacco. Constructs have been transformed into potato leaf discs, and are currently under selection in tissue culture prior to regeneration of whole plants. Early screens conducted at the callus level indicate the functionality

of the cassettes, as determined using a fluorescent protein marker, with green callus emerging. Once regenerated, the nanocompartments will be isolated and analyzed to determine their structural characteristics, and whole plants producing the nanocompartments will be phenotyped in greenhouse experiments.

Results

MoChlo is available for purchase through Addgene. It is our hope that the minimal cost of the kit will encourage other researchers to engage in and further the field of synthetic biology and optimize plants in agricultural production.

4. Associated Knowledge Areas

KA Code	Knowledge Area
511	New and Improved Non-Food Products and Processes

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Competing Public priorities
- Competing Programmatic Challenges

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

• Development of a biosensor method for rapid detection of Salmonella on leafy vegetables. This is crucial for producers, processors, and food testing laboratories seeking new technologies to ensure the safety of the food products, especially raw vegetables.

• Research to prevent the spread of microbial resistance genes and antimicrobial-resistant bacteria in poultry and cattle production .

• Food science research to develop new methods to reduce toxins in milk that are resistant to normal pasteurization techniques.

UT and TSU Extension educated thousands of adults and youth on safe food preservation techniques and safe food handling behaviors. Survey results demonstrate that 65% of participants (1334 of 2045) improved one or more food safety practices. It is estimated that this saved Tennessee $187,344 in reduced foodborne illness costs.

Key Items of Evaluation

UT and TSU Extension educated thousands of adults and youth on safe food preservation techniques and safe food handling behaviors. Survey results demonstrate that 65% of participants (1334 of 2045) improved one or more food safety practices. It is estimated that this saved Tennessee $187,344 in reduced foodborne illness costs.

V(A). Planned Program (Summary)

Program # 9

1. Name of the Planned Program

Forestry, Wildlife, and Fishery Systems

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
102	Soil, Plant, Water, Nutrient Relationships	0%	0%	0%	37%
121	Management of Range Resources	0%	0%	17%	0%
123	Management and Sustainability of Forest Resources	75%	65%	17%	13%
125	Agroforestry	0%	0%	0%	50%
131	Alternative Uses of Land	10%	10%	0%	0%
133	Pollution Prevention and Mitigation	0%	0%	17%	0%
135	Aquatic and Terrestrial Wildlife	10%	10%	0%	0%
136	Conservation of Biological Diversity	0%	0%	17%	0%
201	Plant Genome, Genetics, and Genetic Mechanisms	0%	0%	8%	0%
202	Plant Genetic Resources	0%	0%	7%	0%
206	Basic Plant Biology	0%	10%	0%	0%
311	Animal Diseases	0%	0%	17%	0%
605	Natural Resource and Environmental Economics	5%	5%	0%	0%
	Total	100%	100%	100%	100%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	9.0	2.0	40.0	5.0
Actual Paid	9.0	5.6	8.3	7.0
Actual Volunteer	0.1	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
139267	163842	579175	210437
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
684369	246829	633252	298706
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
432474	52098	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

UT and TSU Extension partnered with the Tennessee Forestry Association to plan and conduct group meetings to inform forest landowners of issues pertaining to forestry and wildlife. Topics included management and marketing. Volunteers were recruited and trained to present at group meetings, provide information, demonstrate equipment and provide materials for demonstrations. UT and TSU Extension provided education at local, regional and statewide events, such as the Tennessee Forest Festival to inform the general public about forest management issues. Demonstrations were provided for landowners and forestry workers. Extension Agents and Specialists educated attendees at County Forestry Landowners Association. UT and TSU Extension worked closely with private consultants, Tennessee Wildlife Resources Agency employees, Tennessee Division of Forestry and others in forestry related industries to develop educational programs and activities for professionals and landowners.

UT and TSU Extension continued one-on-one contacts with landowners throughout the year and used mass media and newsletters to inform the general public on issues and educational opportunities related to natural resources. Both UT and TSU Extension provided leadership for conducting programs that target limited resource landowners with TSU providing specialist leadership for this effort.

UT AgResearch conducted studies on restoring the American chestnut tree and better understanding their pests; establishing native grass forages; water pollution and the health, restoration, and sustainability of fish in their natural environment; and took a One Health approach to investigate pathogen transmissions among wildlife, domesticated species, and humans.

TSU research used remote sensing and GIS technologies to produce enhanced monitoring tools for forestry production, performed research to determine long term site improvement for biofuel production in forest intercropping systems, biomass mapping models to help plan a continuous supply of traditional forest products and help generate revenue in the forests of Tennessee, and the optimization of switchgrass/pine intercropping to enhance soil carbon sequestration and minimize greenhouse gas production.

2. Brief description of the target audience

The target audiences for this program are forest landowners, the forage industry, non-profit environmental organizations, state and federal agency administrators, as well as those who enjoy the state's wildlife resources.

3. How was eXtension used?

.Tennessee Extension professionals are members of Climate, Forestry and Woodlands and Urban Forestry and Energy Conservation Communities of Practice.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	11295	58645	1202	104

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year: 2018

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	2	23	25

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Protect walnut from the walnut twig beetle (Taylor)

Year	Actual
2018	0

Output #2

Output Measure

- Number of logger preferences examined in emerging forest products industries.

Year	Actual
2018	0

Output #3

Output Measure

- Develop mobile apps for IPM (Fulcher, Windham, Hale)
  Not reporting on this Output for this Annual Report

Output #4

Output Measure

- Investigate importance of wildlife to plants (Kwit)
  Not reporting on this Output for this Annual Report

Output #5

Output Measure

- Survey sites to determine presence of Lyme disease vector blacklegged ticks (Hickling)

Year	Actual
2018	71

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Forest Landowner Education: Number of landowners who now understand the ecology of forest development and succession (using forest management plans or contacting a professional forester.)
2	Assess Biomass Feedstock Availability (Hodges, Young)
3	Address Thousand Cankers Disease on black walnut (Grant, Lambdin, Hadziabdic, Windham)
4	Suppress Emerald Ash Borer (Grant, Wiggins)
5	Establish shortleaf pine (Clatterbuck)
6	Deploy predatory beetles against Hemlock Woolly Adelgid (Lambdin, Grant, Parkman, Wiggins)
7	Protect amphibians from ranavirus (Gray)
8	Research to determine long term site improvement for biofuels production in intercropping systems through increased nutrient pools. (Haile)
9	Optimum switchgrass/pine intercropping combination to enhance soil carbon sequestration and minimize greenhouse gas production. (Haile)
10	Biomass mapping models to help plan a continuous supply of traditional forest products, and help generate revenue, and protect and restore supporting services in the forests in Tennessee. (Pokharel)
11	Optimize oak savannah restoration (Keyser, Kwit)
12	Address tick-borne disease in the Southeast (Hickling)
13	Use of remote sensing and GIS technologies to produce enhanced monitoring tools for forestry production in the Southern US (Akumu)
14	Increase in natural reproduction of endangered stream fauna in their natural habitat (Alford)
15	Improved understanding of native grass production systems (Keyser)

Outcome #1

1. Outcome Measures

Forest Landowner Education: Number of landowners who now understand the ecology of forest development and succession (using forest management plans or contacting a professional forester.)

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	101

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources

Outcome #2

1. Outcome Measures

Assess Biomass Feedstock Availability (Hodges, Young)

Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

   Address Thousand Cankers Disease on black walnut (Grant, Lambdin, Hadziabdic, Windham)

   Not Reporting on this Outcome Measure

Outcome #4

1. **Outcome Measures**

   Suppress Emerald Ash Borer (Grant, Wiggins)

   Not Reporting on this Outcome Measure

Outcome #5

1. **Outcome Measures**

   Establish shortleaf pine (Clatterbuck)

   Not Reporting on this Outcome Measure

Outcome #6

1. **Outcome Measures**

   Deploy predatory beetles against Hemlock Woolly Adelgid (Lambdin, Grant, Parkman, Wiggins)

   Not Reporting on this Outcome Measure

Outcome #7

1. **Outcome Measures**

   Protect amphibians from ranavirus (Gray)

2. **Associated Institution Types**

   - 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources
135	Aquatic and Terrestrial Wildlife

Outcome #8

1. Outcome Measures

Research to determine long term site improvement for biofuels production in intercropping systems through increased nutrient pools. (Haile)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

As biofuel production increases, so will the demand for forests and other agricultural biomass for

providing sources of biomass feedstock. The real challenge and opportunity, however, lies on how agricultural and forestry efforts can be integrated to meet future renewable energy demand. For a long-term improvement and sustainability of biofuel production systems, bioenergy feedstock production has to be integrated with existing agricultural production systems, available land, resources, economic systems, and community practice. This study analyzes the agronomic, economic and ecological viability of intercropping of switchgrass and Loblolly pine; findings will have potential to transform the monoculture pattern of cultivation

What has been done
Soil samples were analyzed to assess the performance of agroforestry soil carbon storage and soil carbon quality in time series against monoculture systems. The program also provided series of training workshops for target audiences specifically youth, landowners, extension agents and natural resources professionals.

Results
The current research results show that Soil Organic Carbon (SOC) stock was consistently higher in agroforestry than respective monocrops. SOC concentration and total SOC stocks increased with time and this SOC stocks increase was observed across the five different soil depths among all the levels of intercropping. The study contributes to the growing knowledge of resulting quantify the amount of SOC sequestrated under the intercropping of the plants with divergent growth habit and architecture combination.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
125	Agroforestry

Outcome #9

1. Outcome Measures

Optimum switchgrass/pine intercropping combination to enhance soil carbon sequestration and minimize greenhouse gas production. (Haile)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Low-carbon systems are key for long-term improvement and environmental sustainability of bioenergy feedstock production. Intercropping systems such as agroforestry, that combine energy crops and trees, has the potential to enhance soil carbon sequestration and minimize greenhouse gas release from the system. They may also produce much of the needed biomass for sustainable biofuel production soon, yet only few studies have been conducted regarding its overall performance in this regard. This study examines best management practices of integrating agroforestry systems of loblolly pine and switchgrass to enhance soil carbon sequestration and minimize greenhouse gas production

What has been done
Soil samples were analyzed to assess the performance of agroforestry long term soil carbon storage and soil carbon quality in time series against monoculture systems. The program also provided series of training workshops for target audiences specifically youth, landowners, extension agents and natural resources professionals

Results
Results show that throughout the years of data collection, Soil Organic Carbon (SOC) stock was consistently higher in agroforestry than respective monocrops. The long-term potential use of agroforestry intercropping, however, needs to be assessed considering longer timeframes, and the practice incorporated, and recommendation will be valid where the benefits exceed its alternative land use practice. The educational program allowed participants to examine their properties via aerial photos and terrain maps of the land features, and layout properties boundaries. GIS technology and tools open vast of opportunities to landowners to view, share, and make management decisions regarding their forestland.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
125	Agroforestry

Outcome #10

1. Outcome Measures

Biomass mapping models to help plan a continuous supply of traditional forest products, and help generate revenue, and protect and restore supporting services in the forests in Tennessee. (Pokharel)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Forestry practices have changed the emphasis from traditional timber production to multiple-value forest management. Woody biomass has garnered worldwide interest as an energy source because of its potential to mitigate greenhouse gas emissions, improve national energy security and enhance local economic development. To satisfy the multiple objectives of forest management, timely and accurate information of forest ecosystem health and productivity at multiple scales and resolutions is required. There is an opportunity to leverage geographically extensive Forest Inventory and Analysis data paired with GIS and soil data to develop predictive models of forest site productivity. This offers synergistic benefits with field-based data collection to reduce cost, increase accuracy, and provide new opportunities in forest resources management and utilization through mapping of forest site productivity in Tennessee.

What has been done

A suite of predictor variables and their derivatives from the Digital Elevation Model, National Land Cover dataset, USDA NRCS SSURGO Soil Survey database and Forest Inventory and Analysis were compiled to develop predictive models of site productivity in Tennessee.

Results

Completed 30 x 30 m resolution aboveground woody biomass maps across the state of Tennessee. Such high-resolution maps are important to generate business opportunities to utilize the huge stock of unused biomass without compromising the ecological, economic and social values of Tennessee's valuable forests. A predictive model of site productivity using soil physical and chemical properties as well as some topographic variables was developed. Biomass mapping and evaluating the sustainability of the biomass harvesting project are important milestones from the Agriculture Act 2014, Energy Independence and Security Act 2007 and the Energy Policy Act 2005 to increase production of cellulosic biofuel that not only guarantees national energy security, but also enhances economic development to local communities without compromising soil health and productivity of forest ecosystem.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
123	Management and Sustainability of Forest Resources

Outcome #11

1. Outcome Measures

Optimize oak savannah restoration (Keyser, Kwit)

Not Reporting on this Outcome Measure

Outcome #12

1. Outcome Measures

Address tick-borne disease in the Southeast (Hickling)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
We used a One Health approach to investigate the spread of the vector of Lyme disease - the blacklegged tick Ixodes scapularis into southern states, where existing populations of I. scapularis have not carried a measurable prevalence of B. burgdorferi, the Lyme disease agent.

What has been done
We surveyed 71 sites in the upper Tennessee valley and confirmed that blacklegged ticks are now far more abundant and more widespread than was the case 10 years ago. We also detected for the first time B. burgorferi-infected ticks in 4 Tennessee counties.

Results
Study results suggest that the risk of Lyme disease may soon increase in the regions where B. burgorferi-infected ticks were located. This work will provide Tennessee's public health professionals and veterinarians with information on the risk their patients face from Lyme disease and other tick-borne pathogens in Tennessee and adjacent southeastern states.

4. Associated Knowledge Areas

KA Code	Knowledge Area
311	Animal Diseases

Outcome #13

1. Outcome Measures

Use of remote sensing and GIS technologies to produce enhanced monitoring tools for forestry production in the Southern US (Akumu)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Several stakeholders such as government agencies, land management companies, forest logging companies are continuously seeking updated softwood forest distribution maps in the Southern US for monitoring and forest management activities such as harvesting, pruning, forest fire management and conservation.

What has been done
The classification and mapping of southern yellow pines have been performed. Analyses of vegetation extent, quality and validation efforts have also be carried out. Several satellite datasets have been gathered and used to develop new mapping techniques to improve the detection of southern yellow pines on the landscape.

Results
The project has generated spatio-temporal distribution maps for southern yellow pine stands in Tennessee for the years 1999, 2009 and 2016. Significant change in southern yellow pines distribution and health were found in the periods of study. New softwood delineation mapping techniques have been developed by assimilating sentinel 1 and Landsat 8 satellite datasets.

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources

125	Agroforestry

Outcome #14

1. Outcome Measures

Increase in natural reproduction of endangered stream fauna in their natural habitat (Alford)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Due to a century of industrial pollution, native fauna disappeared from the Pigeon River.

What has been done
Our lab, in partnership with the State water quality and fisheries agencies of Tennessee Conservation Fisheries, Inc., have translocated the Spiny River Snail (Io fluvialis) and the Mountain Madtom (Noturus eleutherus) and stocked the Tangerine Darter (Percina aurantiaca) through hatchery-rearing culture methods on a yearly basis to restore these species to the Pigeon River.

Results
In the Pigeon River, where we have been continuing the nearly 20-year recovery of the native fauna that disappeared due to a century of paper mill pollution, we observed through our annual snorkel monitoring efforts the first successful natural reproduction of the Spiny River Snail (Io fluvialis), Tangerine Darter (Percina aurantiaca), and Mountian Madtom (Noturus eleutherus). Only now have we seen recruitment of juveniles to the Tennessee side of the river, following many years of stocking these species. This provides evidence that restoration of native aquatic species to their natal habitats requires patience and dedication to continue the process, even if you don't achieve expected results for many years.

4. Associated Knowledge Areas

KA Code	Knowledge Area
136	Conservation of Biological Diversity

Outcome #15

1. Outcome Measures

Improved understanding of native grass production systems (Keyser)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Native grasslands can contribute to more agricultural production including beef and biomass for energy as well as providing improved soil health, pollinator habitat, and wildlife habitat. Native grasslands can also improve our ability to deal with severe droughts and reduce production costs for farmers. Research is needed to better understand native grassland production in the eastern U.S. so that information can be shared with experts and producers alike.

What has been done
We conducted sixteen experiments focused on improved efficiency, productivity, and sustainability of native grassland production in the eastern U.S.

Results
Due to improved understanding of appropriate grazing periods, stocking rates, grazing strategies, and integration with biofuels projection, we have developed basic production guidelines for native grasses in forage systems and for conservation. We have shared information about native grassland systems throughout the state and nationally

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

• Government agencies, non-government agencies and forest logging companies are using softwood forest distribution maps developed from remote sensing forestry research to develop forest policies and enhance forest harvesting and planning in Tennessee.
• Developed high-resolution aboveground woody biomass map that are important to generate business opportunities to utilize huge stock of unused biomass without compromising the ecological, economic and social values of Tennessee's valuable forests.
Evaluation of Extension forest landowner education programs demonstrated the following in 2018:

• 141 forest landowners are members in a local County Forestry Association representing 28,043 forest acres.
• 21 forest landowners indicated a willingness to adopt recommended practices presented from the CFA educational programs.
• 85 landowners became aware of the educational modules available from the National Learning Center for Private Forest and Rangeland Owners

Key Items of Evaluation

Evaluation of Extension forest landowner education programs demonstrated the following in 2018:

• 141 forest landowners are members in a local County Forestry Association representing 28,043 forest acres.
• 21 forest landowners indicated a willingness to adopt recommended practices presented from the CFA educational programs.
• 85 landowners became aware of the educational modules available from the National Learning Center for Private Forest and Rangeland Onwers

V(A). Planned Program (Summary)

Program # 10

1. Name of the Planned Program

Health and Safety

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
724	Healthy Lifestyle	70%	70%	0%	0%
805	Community Institutions, Health, and Social Services	30%	30%	0%	0%
	Total	100%	100%	0%	0%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	20.0	1.0	0.0	0.0
Actual Paid	18.0	1.0	0.0	0.0
Actual Volunteer	1.2	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
358114	30910	0	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1759805	46618	0	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
785903	9829	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

In 2018, several health programs were implemented across Tennessee, partnering with different organizations that included the Tennessee Department of Health, to help people improve and prevent chronic diseases. These programs addressed arthritis (Tai Chi), chronic conditions (Living Well with Chronic Conditions), diabetes (Take Charge of Your Diabetes and Diabetes Prevention Program), cancer (TEAM UP TN/Pink and Teal program), and physical activity (Walk Across Tennessee).
The Diabetes Prevention Program is an intensive, evidence-based program that effectively prevents Type 2 diabetes in adults diagnosed with prediabetes. Four agents were trained as lifestyle coaches to deliver this program and two counties offered the program to people at risk for diabetes.e the Tennessee Department of Health, to help people improve their health.

Living Well with Chronic Conditions targeted citizens living with chronic health issues such as asthma, arthritis, and heart disease. Extension will helped these individuals to manage their pain and engage in daily activities.

2. Brief description of the target audience

The target audience is inclusive of consumers and limited resource individuals and families.

3. How was eXtension used?

Tennessee Extension professionals are members of the Creating Healthy Communities and Diabetes Communities of Practice and answer health-related questions,

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	108985	47386070	19660	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	22	0	22

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of exhibits built and displayed to promote program awareness and participation.

Year	Actual
2018	265

Output #2

Output Measure

- Number of research-based publications distributed as part of this program.

Year	Actual
2018	42829

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Arthritis Self-Help Course: Number of participants surveyed who have less pain from their arthritis.
2	Arthritis Self-Help Course: Number of participants surveyed who take fewer medications for their arthritis pain.
3	Dining with Diabetes: Number of participants surveyed who reduced weight.
4	Dining with Diabetes: Number of participants surveyed who eat at least five servings of fruits and vegetables each day.
5	Dining with Diabetes: Number of participants surveyed who use spices and other seasonings to cut back on fat, sugar, and salt.
6	Living Well with Chronic Conditions: Number of participants controlling their anger and frustration caused by their condition by using positive thinking techniques six months after completing the program.
7	Living Well with Chronic Conditions: Number of participants making healthy food decisions six months after completing the program.
8	Living with Chronic Conditions: Number of participants who have had fewer doctor visits and/or emergency room visits six months after completing the program.

Outcome #1

1. Outcome Measures

Arthritis Self-Help Course: Number of participants surveyed who have less pain from their arthritis.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	436

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
724	Healthy Lifestyle
805	Community Institutions, Health, and Social Services

Outcome #2

1. Outcome Measures

Arthritis Self-Help Course: Number of participants surveyed who take fewer medications for their arthritis pain.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	28

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
724	Healthy Lifestyle
805	Community Institutions, Health, and Social Services

Outcome #3

1. Outcome Measures

Dining with Diabetes: Number of participants surveyed who reduced weight.

Not Reporting on this Outcome Measure

Outcome #4

1. Outcome Measures

Dining with Diabetes: Number of participants surveyed who eat at least five servings of fruits and vegetables each day.

Not Reporting on this Outcome Measure

Outcome #5

1. Outcome Measures

Dining with Diabetes: Number of participants surveyed who use spices and other seasonings to cut back on fat, sugar, and salt.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	403

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
724	Healthy Lifestyle
805	Community Institutions, Health, and Social Services

Outcome #6

1. Outcome Measures

Living Well with Chronic Conditions: Number of participants controlling their anger and frustration caused by their condition by using positive thinking techniques six months after completing the program.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	320

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
724	Healthy Lifestyle
805	Community Institutions, Health, and Social Services

Outcome #7

1. Outcome Measures

Living Well with Chronic Conditions: Number of participants making healthy food decisions six months after completing the program.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	254

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
724	Healthy Lifestyle

Outcome #8

1. Outcome Measures

Living with Chronic Conditions: Number of participants who have had fewer doctor visits and/or emergency room visits six months after completing the program.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	175

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
724	Healthy Lifestyle

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Competing Public priorities
- Competing Programmatic Challenges

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Participants reported improvements in their arthritis symptoms, diet, physical activity, diabetes care, and knowledge about cancer across UT and TSU Extension Health Programs. Results included:

- 93% (401 of 472) participants improved performance of daily activities through Tai Chi
- 91% (2,686 of 2,938) plan to continue to exercise after participating in the Walk Across Tennessee Program
- 94% (926 of 1126) participants plan to get age and gender appropriate cancer screenings as a result of TEAM UP TN information
- 32 participants in the Diabetes Prevention Program lost 348 pounds in one year
- The economic impact of these health initiatives is estimated at $9,604,643 for the 9633 participants who benefitted from UT and TSU Extension Health Programs

Key Items of Evaluation

Participants reported improvements in their arthritis symptoms, diet, physical activity, diabetes care, and knowledge about cancer across UT and TSU Extension Health Programs. Results included:

- 93% (401 of 472) participants improved performance of daily activities through Tai Chi
- 91% (2,686 of 2,938) plan to continue to exercise after participating in the Walk Across Tennessee Program
- 94% (926 of 1126) participants plan to get age and gender appropriate cancer screenings as a result of TEAM UP TN information
- 32 participants in the Diabetes Prevention Program lost 348 pounds in one year
- The economic impact of these health initiatives is estimated at $9,604,643 for the 9633 participants who benefitted from UT and TSU Extension Health Programs

V(A). Planned Program (Summary)

Program # 11

1. Name of the Planned Program

Horticultural Systems

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
102	Soil, Plant, Water, Nutrient Relationships	0%	0%	2%	0%
111	Conservation and Efficient Use of Water	0%	0%	10%	0%
201	Plant Genome, Genetics, and Genetic Mechanisms	0%	0%	10%	0%
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants	0%	0%	2%	0%
205	Plant Management Systems	12%	12%	12%	0%
211	Insects, Mites, and Other Arthropods Affecting Plants	45%	45%	2%	33%
212	Pathogens and Nematodes Affecting Plants	11%	11%	16%	17%
213	Weeds Affecting Plants	0%	0%	3%	0%
215	Biological Control of Pests Affecting Plants	0%	0%	2%	8%
216	Integrated Pest Management Systems	10%	10%	9%	42%
502	New and Improved Food Products	0%	0%	10%	0%
601	Economics of Agricultural Production and Farm Management	22%	22%	0%	0%
604	Marketing and Distribution Practices	0%	0%	1%	0%
607	Consumer Economics	0%	0%	1%	0%
701	Nutrient Composition of Food	0%	0%	10%	0%
702	Requirements and Function of Nutrients and Other Food Components	0%	0%	10%	0%
	Total	100%	100%	100%	100%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	36.0	5.0	25.0	10.0
Actual Paid	27.0	5.6	15.7	11.2

Actual Volunteer	9.4	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
576962	163842	1185097	336699
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
2835241	246829	914643	477930
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
324421	52098	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Researched best practices for pest and disease management
- Studied water management for ornamental plants
- Investigated the human health promoting properties natural products
- Studied best management practices for turfgrass
- Developed new trap designs and strategies for Ambrosia beetle available to growers.
- Enhanced nursery production efficiency through readily-adopted chemical, biorational and cultural techniques to reduce soil-borne disease.
- Developed environmentally friendly products to control disease on food crops.
- Improved understanding of pest management treatment options and reduced-risk pest control options for end-user nursery growers.
- Developed new treatment options, reduced costs, lower environmental pesticide inputs, for insect control on horticultural crops.
- Research to develop changes to quarantine guidelines for Japanese beetle and imported fire ant.
- Identified new nursery crop production practices to reduce the use of synthetic pesticides

2. Brief description of the target audience

- Farmers/producers who have traditional livestock and tobacco operations, but are looking to improve income through the Green Industry.
- Master Gardeners who volunteer to provide community service through horticulture.
- Business owners who need research-based information to start, maintain or expand their greenhouse, landscaping, or nursery business.
- Regulatory agencies (e.g., U.S. Environmental Protection Agency, USDA-APHIS, Tennessee Department of Agriculture).
- Agrochemical manufacturers
- Food scientists, nutritionists, and physicians with interest in human health impact of botanicals
- Students (high school, undergraduate, and graduate) and postdoctoral trainees

3. How was eXtension used?

Tennessee Extension professionals were members of several Communities of Practice related to horticulture:

- Consumer Horticulture
- All About Blueberries
- Imported Fire Ants
- Ant Pests
- Garden Professors
- Urban Integrated Pest Management
- Grapes
- Bee Health

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	366189	47502463	34018	220

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	18	39	57

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Horticultural workshops and conferences.

Year **Actual**

2018	8785

Output #2

Output Measure

- Number of exhibits displayed to teach best practices in horticultural systems.

Year	Actual
2018	133

Output #3

Output Measure

- Number of research-based publications distributed as part of this program.

Year	Actual
2018	739100

Output #4

Output Measure

- Factsheets about alternative methods to control disease and insects in nursery production.

Year	Actual
2018	0

Output #5

Output Measure

- Develop Drought- and Temperature-Tolerant Grapes (Cheng)
  Not reporting on this Output for this Annual Report

Output #6

Output Measure

- Employ Nematodes for Biological Pest Control (An)
  Not reporting on this Output for this Annual Report

Output #7

Output Measure

- Number of people who learned about rose rosette disease research (Windham)

Year	Actual
2018	727

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Consumer Horticulture: Number of consumers who applied fewer fertilizers and pesticides due to a better understanding of landscape best management practices.
2	Consumer Horticulture: Number of consumers who learned about plant selection and proper planting to save money and time in the landscape.
3	New trap designs and strategies for Ambrosia beetle available to growers. (Addesso)
4	Assess and Reintroduce Pityopsis ruthii (Trigiano, Wadl)
5	Enhance Gentic diversity in dogwood cultivars (Windham, Windham, Trigiano, Wadl)
6	Control Downy Mildew (Lamour, Trigiano)
7	Enhance Greenhouse Production (Deyton, Sams)
8	Develop Molecular Markers for Horticultural Traits (Trigiano, Ownley, Wadl)
9	Use Genetics Against Phytophthora Blight (Lamour)
10	Improved understanding of pest management treatment options and reduced-risk pest control options by end-user nursery growers. (Oliver)
11	Development of new treatment options, reduced costs, lower environmental pesticide inputs, or reduced risk from lower rates or new chemistries with less acute toxicity. (Oliver)
12	Research to develop changes to quarantine guidelines for Japanese beetle and imported fire ant. (Oliver)
13	Determine the current labor use by small Tennessee farmers and the degree of off-farm employment by small farmer. (Tegegne)
14	Development of Best Management Practices for labor use by small farmers in Tennessee. (Tegegne)
15	Enhancing sustainable plant health through identification and characterization of microbes with bioactivity against diverse fungal diseases, insects and environmental stress for use as microbial pesticides for pathogens, and in improving plant growth. (Mmbaga)
16	Enhance nursery production efficiency through readily-adopted chemical, biorational and cultural techniques to reduce soil-borne disease. (Baysal-Gurel)
17	Decrease ground and surface water contamination in nursery production through identification of new nursery crop production practices to reduce the use of synthetic pesticides. (Witcher)

18	Develop Bioactive Natural Products for Plant Protection (Gwinn, Chen, Ownley, Bernard)
19	Address Viruses of Grapevine (Hajimorad)
20	Development of environmentally friendly products to control disease on food crops. (Mmbaga)
21	Extension Enhances Commercial Fruit and Vegetable Production in Tennessee
22	Extension Provides Turfgrass Education Programs for Homeowners
23	Plant Disease and Insect Management for Tennessee's Green Industry
24	Improved understanding of Asian dogwood (Cornus kousa) lineage (Trigiano)
25	Increase in water management efficiency in ornamental crop production (Fulcher)

Outcome #1

1. Outcome Measures

Consumer Horticulture: Number of consumers who applied fewer fertilizers and pesticides due to a better understanding of landscape best management practices.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	3163

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Pathogens and Nematodes Affecting Plants
213	Weeds Affecting Plants
216	Integrated Pest Management Systems

Outcome #2

1. Outcome Measures

Consumer Horticulture: Number of consumers who learned about plant selection and proper planting to save money and time in the landscape.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	7138

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Pathogens and Nematodes Affecting Plants
213	Weeds Affecting Plants
216	Integrated Pest Management Systems

Outcome #3

1. Outcome Measures

New trap designs and strategies for Ambrosia beetle available to growers. (Addesso)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Ambrosia beetles are serious pests of trees and shrubs in nursery production. The beetles tunnel into the bark and excavate galleries which can girdle the tree and kill it. The beetles feed on symbiotic fungus they inoculate into the bark tissue which can cause diseases in some plants.

What has been done
Two potential ethanolic compounds were tested in second year trials as repellents. In addition, five already formulated and commercially available products were tested as repellents.

Results
Two ethanolic compounds were evaluated in lab and field experiments alone and in combination to repel ambrosia beetles. For a second year. GC-EAD results suggest that the beetles can smell both compounds and that the electrical signals are additive. The results were more variable than in the previous study. More research is needed to determine behavioral activity in the field. The two most active formulated products will be tested for a second year and evaluates in combination with attractants to determine whether they can provide protection to trees in the field.

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants

Outcome #4

1. **Outcome Measures**

Assess and Reintroduce Pityopsis ruthii (Trigiano, Wadl)

Not Reporting on this Outcome Measure

Outcome #5

1. **Outcome Measures**

Enhance Gentic diversity in dogwood cultivars (Windham, Windham, Trigiano, Wadl)

Not Reporting on this Outcome Measure

Outcome #6

1. **Outcome Measures**

Control Downy Mildew (Lamour, Trigiano)

Not Reporting on this Outcome Measure

Outcome #7

1. **Outcome Measures**

Enhance Greenhouse Production (Deyton, Sams)

Not Reporting on this Outcome Measure

Outcome #8

1. **Outcome Measures**

Develop Molecular Markers for Horticultural Traits (Trigiano, Ownley, Wadl)

Not Reporting on this Outcome Measure

Outcome #9

1. Outcome Measures

Use Genetics Against Phytophthora Blight (Lamour)

Not Reporting on this Outcome Measure

Outcome #10

1. Outcome Measures

Improved understanding of pest management treatment options and reduced-risk pest control options by end-user nursery growers. (Oliver)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Ornamental nurseries grow a more diverse mixture of plant genera and species than monoculture farming systems like traditional row crops. Consequently, nursery producers must deal with multiple pest and disease issues at any given time. In addition, a large number of non-indigenous species have been introduced into the U.S. and the invasive nature of many of these species and the costly quarantine programs often associated with them pose a constant challenge to nursery operations. With the complexity of pest issues in nursery agroecosystems, it is important to provide producers and stakeholders with current research information to maximize their knowledge on successful, sustainable, and profitable control tactics via workshops and field days, educational materials like factsheets, and other outlets like webinars and one-on-one training

What has been done
Field and laboratory research was performed to address key management issues for quarantine pests that included imported fire ant (IFA) and Japanese beetle (JB) and trunk-attacking insects including flatheaded borer and ambrosia beetles. Research included neonicotinoid alternatives for larval JB quarantine treatments and prevention of flathead borer trunk attacks, residual activity of permethrin against ambrosia beetles and evaluation of systemic fungicides and proprietary semiochemicals on ambrosia beetles, temperature effects on the efficacy of JB balled and

burlapped root ball and container plant dip treatments, new methods to infest container plants with JB eggs for evaluation of insecticide treatments, pyrethroid band spray treatments for IFA quarantine control, introductions of Solenopsis invicta virus (SINV-3) against hybrid IFA populations, and evaluations of a new bifenthrin formulation for improvement of both IFA and JB container treatments.

Results

Information on IFA, JB, flatheaded borer, and ambrosia beetle management was shared with nursery growers, extension, USDA, Tennessee Department of Agriculture, and scientists at educational events including an invited presentation to the Central Plant Board. Three new extension bulletins were developed on IFA and hemlock woolly adelgid management with one of the IFA publications being a regional article on IFA management in agricultural areas developed by multiple University partners. A new training module on advanced pesticide concepts was developed for the Tennessee Master Nursery Program (TMNP) and the quarantine insects module was updated.

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
216	Integrated Pest Management Systems

Outcome #11

1. Outcome Measures

Development of new treatment options, reduced costs, lower environmental pesticide inputs, or reduced risk from lower rates or new chemistries with less acute toxicity. (Oliver)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Numerous insect pests in nurseries require frequent insecticide treatments to reduce levels of plant damage or to meet mandatory quarantine requirements. Examples include trunk-damaging borers like ambrosia beetle and flatheaded borers, and cryptic quarantine pests that are easily transported in nursery plant soils like Japanese beetle larvae and imported fire ants. The

development of new product alternatives, especially reduced- risk treatments, and better treatment methodologies, is important for protecting agricultural workers, the environment, and ensuring treatments remain viable and available to agricultural producers.

What has been done

New treatment options for insect pests were investigated in several field and laboratory trials, including permethrin residual activity for ambrosia beetle control, liquid and granular anthranilic diamide efficacy as a Japanese beetle (JB) pre-harvest band spray treatment for field-grown nursery stock, a long-term evaluation of Acelepryn versus imidacloprid systemic insecticides for flatheaded borer control, continued evaluation of systemic fungicides and new proprietary semiochemicals for preventing invasive ambrosia beetle damage, and new container treatments for JB and imported fire ant (IFA). Non-pesticide options like cover crops also were investigated for flatheaded borer, and Solenopsis invicta virus (SINV-3) was evaluated for establishment in Tennessee hybrid IFA populations. New techniques to infest container nursery stock with JB eggs were tested to facilitate testing of new chemical treatments.

Results

Findings include: 1) permethrin residual activity against ambrosia beetles lasted about 3 weeks and irrigation did not reduce efficacy, potentially allowing producers to apply the barrier spray treatments less frequently, 2) Acelepryn liquid and granular treatments were more efficacious against JB than Mainspring treatments and more work will continue with the granular formulation in 2019, 3) Acelepryn may have protective effects that is less toxic to pollinators than the current imidacloprid treatment, 4) two proprietary semiochemical treatments under evaluation reduced ambrosia beetle attacks on nursery tree and have promise for management programs, 5) cover crop vegetation in nursery crops reduced flatheaded borer trunk attacks and did reduce the need for insecticide treatments, 6) SINV-3 did not establish in Tennessee hybrid IFA sites and it appears this virus isolate originating from red IFA populations may not be infectious to hybrid IFA, and 7) several methods increased JB oviposition into containerized substrates and could be useful for chemical efficacy studies, but the most effective method was a buried JB trap that allowed adult beetles to self-infest container soils.

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
216	Integrated Pest Management Systems

Outcome #12

1. Outcome Measures

Research to develop changes to quarantine guidelines for Japanese beetle and imported fire ant. (Oliver)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Imported fire ants (IFA) and Japanese beetle (JB) populations continue to spread into new areas in the United States. Both of these pests require expensive certification treatments to ensure insects are not shipped to new areas. Most of the current IFA and JB quarantine protocols for field-grown nurseries are expensive, rely extensively on one of only three active ingredients, and have potential worker exposure issues from repeated site reentries or post-treated plant handling. More options are needed with lower cost, reduced-risk to farm labor, and greater efficacy to ensure these pests are not shipped to new areas.

What has been done
Research was performed to address specific concerns with JB and IFA quarantines. A third year of testing anthranilic diamides against early instar JB indicated Acelepyrn liquid and granular treatments were as effective as current imidacloprid and thiamethoxam neonicotinoid pre-harvest JB Harmonization Plan (JBHP) treatments. Fire ant data from multiple trials has been summarized in three new protocols developed and shared with USDA-APHIS to facilitate future research priorities and treatment planning.

Results
A report of Mainspring and Acelepryn data from JB tests was sent to an agrochemical company and the JB Harmonization Plan (JBHP) Regulatory Treatment Review Committee and is under evaluation at this time as a new Acelepyrn pre-harvest JB treatment in the JBHP. The Acelepryn treatment would be the first non-neonicotinoid pre-harvest treatment alternative, and Acelepryn also is potentially less harmful to pollinators than neonicotinoids. Data from IFA field trials also was shared with USDA-APHIS to guide planning for additional research trials. USDA-APHIS is presently considering a new IFA balled and burlapped root ball drench and injection treatment with bifenthrin for root balls under 15 inch diameter. The new IFA treatment would replace the current chlorpyrifos drench treatment, an insecticide that is under review by the Department of Justice for possible elimination.

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
216	Integrated Pest Management Systems

Outcome #13

1. **Outcome Measures**

Determine the current labor use by small Tennessee farmers and the degree of off-farm employment by small farmer. (Tegegne)

Not Reporting on this Outcome Measure

Outcome #14

1. **Outcome Measures**

Development of Best Management Practices for labor use by small farmers in Tennessee. (Tegegne)

Not Reporting on this Outcome Measure

Outcome #15

1. **Outcome Measures**

Enhancing sustainable plant health through identification and characterization of microbes with bioactivity against diverse fungal diseases, insects and environmental stress for use as microbial pesticides for pathogens, and in improving plant growth. (Mmbaga)

Not Reporting on this Outcome Measure

Outcome #16

1. **Outcome Measures**

Enhance nursery production efficiency through readily-adopted chemical, biorational and cultural techniques to reduce soil-borne disease. (Baysal-Gurel)

2. **Associated Institution Types**

- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Soil-borne diseases can be a major limitation to field production of woody ornamentals, particularly for propagation ground bed systems. Soil-borne pathogens have been documented as the most economically important pathogens. Soil-borne diseases are often difficult to control, and cannot be managed solely through the use of crop rotations, improved disease-resistant varieties, and chemical control. Therefore, providing improved, efficacious, cost-effective, sustainable and environmentally friendly recommendations for soil-borne disease management to the nursery industry is very important.

What has been done

Chemical and biorational products were evaluated for ability to control Phytophthora root rot of dogwood, hydrangea and Rhizoctonia root rot of Viburnum. Based on the outcome of the greenhouse study from 2017 research results, selected biofumigation cover crops in the Brassicaceae family (such as mustard, mighty mustard, turnip, radish and astro arugula) in combination with solarization, good quality compost, mustard meal amendment and solarization alone were evaluated for their ability in controlling soilborne diseases in both field and on-farm experiments.

Results

Fungicides were identified that produced significant reductions in Phytophthora root rot and Rhizoctonia root rot. These findings are of significant interest to nursery producers and were communicated via new fact sheets and presentations. Additionally, in both field and on-farm experiments both solarization alone or in combination with biofumigant cover crop incorporation significantly reduced root rot diseases compared to the non-treated controls. In on-farm experiments, there were no significant differences among 6-weeks soil solarization alone and 2-weeks solarization in combination with biofumigant cover crop incorporation in root rot disease severity.

4. Associated Knowledge Areas

KA Code	Knowledge Area
212	Pathogens and Nematodes Affecting Plants
216	Integrated Pest Management Systems

Outcome #17

1. Outcome Measures

Decrease ground and surface water contamination in nursery production through identification of new nursery crop production practices to reduce the use of synthetic pesticides. (Witcher)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Weed pests are a continuous problem in woody ornamental crop production. Post-emergent herbicides such as glyphosate are commonly used to control weeds in field-grown nursery crops, yet many weeds have developed glyphosate resistance. Numerous post-emergent herbicide applications are required throughout the year for effective control, but pre-emergent herbicides could be utilized to prevent the establishment of new weeds and be used to control glyphosate resistant weeds. Rapidly identifying glyphosate resistant weeds and developing effective control practices would reduce herbicide use and production costs for growers.

What has been done
Whole plant assays were conducted to confirm glyphosate resistance in horseweed plants and to evaluate the effect glyphosate rate had on glyphosate susceptible and resistant horseweed plants. A leaf dip assay was evaluated as a tool for rapidly detecting glyphosate resistance in horseweed and to identify thresholds for resistance. Various pre-emerge herbicides and herbicide combinations were applied to field-grown nursery crops in late fall and early spring to evaluate weed control longevity and to determine the most effective products.

Results
Glyphosate treatments did not reduce resistant horseweed growth compared with non-treated plants while susceptible horseweed plants had a 50% or greater reduction in growth compared with non-treated plants. Resistant plants were tolerant of glyphosate when applied at a rate 5 times greater than the labeled rate. In the leaf dip assay, leaves of glyphosate resistant horseweed were not damaged by up to 11.7 L/ha of glyphosate, whereas leaves of susceptible horseweed were severely damaged by glyphosate at 2.3 L/ha or greater. In the pre-emergent herbicide evaluation, fall applied herbicides provided longer weed control residual then the spring applications. For the fall application, several herbicides provided over 90% weed control at 6 months including indaziflam, oxadiazon, isoxaben+prodiamine, simazine+prodiamine, and flumioxazin.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems

Outcome #18

1. Outcome Measures

Develop Bioactive Natural Products for Plant Protection (Gwinn, Chen, Ownley, Bernard)

Not Reporting on this Outcome Measure

Outcome #19

1. Outcome Measures

Address Viruses of Grapevine (Hajimorad)

Not Reporting on this Outcome Measure

Outcome #20

1. Outcome Measures

Development of environmentally friendly products to control disease on food crops. (Mmbaga)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
There is a need to increase the diversity of eco-friendly products that are effective in disease management and are safe to human health, non-target organisms, and environmental quality. Using microorganisms as biological control agents (BCA) against plant disease is an attractive eco-friendly strategy for combating plant diseases. The BCAs antagonize pathogens directly by hyper-parasitism, predation, and production of antibiotics and lytic enzymes; and indirectly by competing for space and nutrients, inducing plant defense system against pathogens and promoting plant growth.

What has been done
The ability of selected BCAs to promote plant growth was evaluated and measured by plant weight, plant height, leaf size and chlorophyll content. Crops used for the experiments were cucumbers, squash, tomatoes, sweet pepper and green beans and diseases evaluated were cucurbit powdery mildews and root rots caused by Phytophthora capsici, Sclerotium rolfsii and Macrophomina phaseolina. These evaluations are continuous and some results on green beans have been confirmed in greenhouse and field environments, while evaluations on cucumbers, tomatoes, sweet pepper was done in growth chambers and greenhouse and need to be repeated in greenhouse and field

Results
BCA application by spraying against foliage diseases and drenching and seed treatment against root rots were effective; different isolates and different plant/isolate interactions exhibited significant differences in disease suppression. These evaluations are continuous and some results on green beans have been confirmed in greenhouse and field environments, while evaluations on cucumbers, tomatoes, sweet pepper was done in growth chambers and greenhouse and need to be repeated in greenhouse and field

4. Associated Knowledge Areas

KA Code	Knowledge Area
212	Pathogens and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems

Outcome #21

1. Outcome Measures

Extension Enhances Commercial Fruit and Vegetable Production in Tennessee

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
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.

What has been done
UT Extension programming in fruit and vegetable production resulted in over 34,500 direct contacts in 2018. Best production and management practices were taught at 306 group meetings and 627 on-site visits. Over 250 social media outlets, radio programs, TV stories, newspaper articles and other publications reaching over 3.8 million stakeholders supported the direct education efforts.

Results
The total economic impact of Extension's commercial fruit and vegetable horticultural programming was estimated at over $1.3 million in increased savings, increased income, and one-time capital purchases by adopting good agricultural practices, season extension and/or organic production practices. Impacts included:
-235 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
-267 fruit and vegetable producers adopted good agricultural practices on 3,914 acres to improve food safety and enhance marketing opportunities

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems

Outcome #22

1. Outcome Measures

Extension Provides Turfgrass Education Programs for Homeowners

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Many Tennessee homeowners enjoy maintaining their lawns and landscapes. According to a survey of the Tennessee Turfgrass Industry conducted in 2014/2015 by UT faculty, homeonwers throughout the state accounted for an estimated $4.4 billion (about 79%) of the more than $5 billion total contributed by the industry to the state's economy.

What has been done
Resources were developed for educational programs and to answer questions related to turfgrass management. Over 1190 direct contacts were made related to turfgrass management. More than 500 interns received residential turf management training during Tennessee Master Gardener

programs.

Results
Tennessee Extension Turfgrass Management programs resulted in the following impacts:
-160 homeonwers who received information indicated that they planned to make a positive change related to proper use of fungicide, herbicides and/or insecticide; plant improved turfgrass varieties; elevate cutting heights; apply fertilizer at recommended times; and remove excess thatch and relieve soil compaction.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
205	Plant Management Systems

Outcome #23

1. Outcome Measures

Plant Disease and Insect Management for Tennessee's Green Industry

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Plant diseases and insects cause millions of dollars of damage to turfgrass and ornamental plants in residential and commercial landscapes, nurseries, and greenhouses in Tennessee each year. A key to pest management is the identification of the target pest or disease so that appropriate management strategies can be implemented. Emphasis in many educational processes has been placed on identifying pests and diseases and reliable sources of information for green industry professionals and Master Gardeners.

What has been done
UT Extension conducted educational programs in consumer and commercial horticulture. Pest and disease identification and management were taught by Extension educators at group meetings and site visits. These Extension personnel reached 144,662 direct contacts in 53

counties in 2018.

Results

Educational activities across the state were evaluated to determine the following commercial and consumer horticulture impacts:
-706 landscape and nursery participants increased their knowledge of fire ant management
-127 green industry personnel adopted an integrated pest management approach to insect, mite and disease control in turfgrass and/or ornamentals
-109 green industry personnel increased business profitability and sustainability through improved insect, mite and disease control in turfgrass and/or ornamental plants
-168 green industry personnel learned to correctly identify pest insects, mites and diseases of turfgrass and/or ornamental plants
-2,889 professional turfgrass managers began using new, more environmentally-friendly pesticides over older pesticide chemistries
-112 industry professionals are dethatching, aerifying and controlling turfgrass pests according to UT Extension recommendations

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants

Outcome #24

1. Outcome Measures

Improved understanding of Asian dogwood (Cornus kousa) lineage (Trigiano)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Cornus florida (flowering dogwood) and Cornus kousa (Asian dogwood) are important plants for the nursery industry. C. florida cultivars are susceptible to powdery mildew and dogwood anthracnose, negatively affecting sales, while the C. kousa cultivars are tolerant to these

diseases but do not grow well in the southern U.S. Combining desired horticultural traits and disease resistance from C. florida and C. kousa is advantageous to the nursery industry. Studies are necessary to better understand genetics and inheritance in this species to optimize hybrids with preferred traits.

What has been done

To assess the genetic diversity of Asian dogwoods, samples of gDNA from 130 C. kousa plants of non-cultivated Asian origin (China, Japan, Korea) were collected. Both living trees and herbarium specimens dated as early as 1950s were sampled. The collection was analyzed using 18C. kousa-specific microsatellite markers. The dataset was then subjected to the population genetics analysis using R with several relevant packages.

Results

The majority of our dataset (locus- and population-wise) remained under the Hardy-Weinberg Equilibrium assumptions and showed high gene flow as expected from an obligate outcrossing species. Analysis of molecular variance indicated the overwhelming majority of variance partitioned among subpopulations and individuals. Among the five subpopulations (China current and old, Japan current and old, Korea old), the genetic variation accounted for 8.5% of total variation, yet demonstrated clear population structure according to the country of origin. Population structure indicated the presence of three population clusters matching the country of origin. Low genetic differentiation of our collection was attributed to the mutations accrued over time. The Neighbor-Joining tree of population distances indicated the samples from Japan as the most ancestral. These results have important implications for future cultivar development, indicating that multiple sources of diversity may be used for breeding.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms

Outcome #25

1. Outcome Measures

Increase in water management efficiency in ornamental crop production (Fulcher)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The multi-million dollar green industry grows many of its crops in containers. Irrigation scheduling is important for efficient water management and reduced runoff water purposes.

What has been done
Flow meters, substrate moisture sensors, and leachate gauges were deployed at a local nursery and at an on-campus production facility. Researchers investigated and optimized irrigation practices and substrate components of nursery crops as part of a multi-crop water use study across Tennessee. Substrate moisture level, water consumption, and leachate were measured and used in real-time, feedback-based systems to control irrigation with the goal of identifying a basis for irrigation scheduling that will reduce nursery water use.

Results
At the collaborating nursery, a system based on maintaining a 15% leachate fraction was trialed using a high water use plant, Hydrangea paniculata, Little Lime and coconut coir compared with the nursery standard of irrigating every other day and potting in 100% pine bark. The system reduced water use approximately 49% for Little Lime hydrangea.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Government Regulations
- Competing Programmatic Challenges

Brief Explanation

{No Data Entered}

V(I). Planned Program (Evaluation Studies)

Evaluation Results

• Tennessee nursery growers have been informed of the potential for using pre-treatments of fungicides and repellents as management options for suppressing ambrosia beetle attacks on vulnerable trees.
• Development of environmentally friendly microorganisms to be used for control of diseases in food crops
• New Imported Fire Ant treatments would replace the current chlorpyrifos drench treatment, an insecticide that is under review by the Department of Justice for possible

elimination.

- Provide information to US Japanese Beetle Harmonization Board about new control strategies that do not use neonicotinoids, which have been under increased scrutiny for possible negative effects on pollinators.
- Alternative pesticide approaches were developed to supplement or eliminate current insecticide-based beetle management.
- Develop methods to rapidly identify Roundup-resistant weeds. This will lead to more efficient weed management through the use of alternative practices, including the more-efficient pre-emergent herbicides.

In 2018, we conducted an evaluation of Extension residential and consumer horticulture programs including the Tennessee Extension Master Gardener Program (TEMG). Evaluation results showed:

- 8386 residents received information on home fruit and vegetable production
- Tennessee Extension Master Gardeners taught 528 educational presentations that reached 13,853 residents
- Master Gardeners managed 113 landscape and ornamental gardens that demonstrated sustainable practices

Key Items of Evaluation

In 2018, we conducted an evaluation of Extension residential and consumer horticulture programs including the Tennessee Extension Master Gardener Program (TEMG). Evaluation results showed:

- 8386 residents received information on home fruit and vegetable production
- Tennessee Extension Master Gardeners taught 528 educational presentations that reached 13,853 residents
- Master Gardeners managed 113 landscape and ornamental gardens that demonstrated sustainable practices

V(A). Planned Program (Summary)

Program # 12

1. Name of the Planned Program

Human Development

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
802	Human Development and Family Well-Being	100%	100%	0%	0%
	Total	100%	100%	0%	0%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	17.0	2.0	0.0	0.0
Actual Paid	13.5	2.0	0.0	0.0
Actual Volunteer	2.8	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
278533	61866	0	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1368737	93307	0	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
507156	19672	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Programs that promote positive human development were implemented that focused on issues such as positive parenting (Active Parenting, Girl Talk, Guy Talk), anger management (RELAX Anger

Management), healthy relationships (Co-Parenting), and manage the impact of technology in their lives (Digi-Life). In addition, UT Extension afterschool programming served about 300 students in kindergarten through 8th grade. These programs worked with youth to help improve reading and math scores and to reduce absenteeism.

For 2017-2021, TSU Extension Family and Community Health programs will place special emphasis on "Healthy Aging" for the mind, body and spirit. The ultimate goal is to increase knowledge and education relating to healthy aging. Tennessee is getting older. Various assessments have shown that the percentage of Tennessee's population over the age of 65 will grow to 20% by 2025 (up from about 12% at the beginning of the 21st Century). TSU Extension will produce and distribute resource materials and educational programs on a variety of topics for interested individuals, caregivers, and professionals. Various methods will be employed, including inter-generational connections.

2. Brief description of the target audience

The target audiences for this planned program are Tennessee child care providers, parents, and adolescents. While all parents of infants and young children are targeted for literacy programs, parents seeking a divorce are especially targeted for parenting instruction because of the added demands of co-parenting. Tennessee child care providers working full-time are required to have 18 hours and child care center directors are required to have 24 hours of instruction annually. Tennessee parents seeking a divorce are directed by the courts to a four-hour co-parenting class. In many communities in the state, Extension is the only provider of this instruction.

3. How was eXtension used?

Tennessee Extension professionals were involved in several Communities of Practice related to human development topics:

- Families and Child Well-Being Learning Network
- Just in Time Parenting
- Mental Health
- Military Families
- Family Caregiving

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	118291	9198747	30584	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	1	0	1

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of exhibits displayed to promote program awareness and participation.

Year	Actual
2018	98

Output #2

Output Measure

- Number of research-based publications distributed as part of this program.

Year	Actual
2018	74687

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Child Care/Parenting: Number of parents and childcare providers who report using suggested guidance techniques more often.
2	Child Care/Parenting: Number of parents and child care providers who report putting down or blaming their child less.
3	Child Care/Parenting: Number of parents and child care providers who report talking, singing and playing more with their children than before the program.
4	Divorcing Parents: Number of parents who plan to decrease exposure of their children to parental conflict.
5	Caregiving Education: Number of caregivers who report the Extension program helped them to minimize stress.

Outcome #1

1. Outcome Measures

Child Care/Parenting: Number of parents and childcare providers who report using suggested guidance techniques more often.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	729

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
802	Human Development and Family Well-Being

Outcome #2

1. Outcome Measures

Child Care/Parenting: Number of parents and child care providers who report putting down or blaming their child less.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	69

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
802	Human Development and Family Well-Being

Outcome #3

1. Outcome Measures

Child Care/Parenting: Number of parents and child care providers who report talking, singing and playing more with their children than before the program.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	51

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
802	Human Development and Family Well-Being

Outcome #4

1. Outcome Measures

Divorcing Parents: Number of parents who plan to decrease exposure of their children to parental conflict.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1039

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
802	Human Development and Family Well-Being

Outcome #5

1. Outcome Measures

Caregiving Education: Number of caregivers who report the Extension program helped them to minimize stress.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	865

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
802	Human Development and Family Well-Being

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Government Regulations

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

In 2018, training was conducted with 1302 child care providers to help retain qualified, well-trained providers. The BRIGHT FUTURES training resulted in:

- 83% more confident in their ability as child care providers
- 92% more likely to use two or more practices to promote positive child behavior after the training
- 90% improved communication with parents

For the 300 students who participated in UT Extension afterschool programs, the following results were reported:

- 65% improved math scores
- 56% improved reading scores
- 100% reduced chronic absenteeism

Key Items of Evaluation

In 2018, training was conducted with 1302 child care providers to help retain qualified, well-trained providers. The BRIGHT FUTURES training resulted in:

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- 56% improved reading scores
- 100% reduced chronic absenteeism

V(A). Planned Program (Summary)

Program # 13

1. Name of the Planned Program

Sustainable Energy

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
102	Soil, Plant, Water, Nutrient Relationships	0%	5%	0%	11%
132	Weather and Climate	0%	0%	0%	11%
201	Plant Genome, Genetics, and Genetic Mechanisms	0%	0%	43%	22%
205	Plant Management Systems	0%	0%	0%	11%
215	Biological Control of Pests Affecting Plants	0%	5%	0%	0%
402	Engineering Systems and Equipment	0%	10%	29%	0%
511	New and Improved Non-Food Products and Processes	0%	0%	26%	12%
512	Quality Maintenance in Storing and Marketing Non-Food Products	80%	60%	0%	0%
601	Economics of Agricultural Production and Farm Management	0%	0%	0%	33%
603	Market Economics	10%	5%	0%	0%
605	Natural Resource and Environmental Economics	10%	10%	0%	0%
607	Consumer Economics	0%	5%	0%	0%
611	Foreign Policy and Programs	0%	0%	2%	0%
	Total	100%	100%	100%	100%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	5.0	1.0	60.0	7.0
Actual Paid	4.5	4.0	9.8	9.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
99476	150194	821423	270561
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
488835	226117	715066	384051
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	47601	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

• Disseminated research findings to the scientific community, stakeholders, agricultural, environmental, life science industries.
• Recruited and trained students and postdoctoral researchers, incorporating research training into teaching and extension curricula.
• Developed and evaluated bio-based fibrous products for eco-friendly crop protection.
• Developed efficient technologies for food and bioprocess engineering.
• Conducted experiments using biotechnology to enhance plants.
• Optimized switchgrass biomass and soil respiration via biochar and nitrogen.
• Documented the growth performance, environmental conditions, and agronomy practices for alternative biomass production in the Southeast.
• Created economic opportunities for small and medium sized farmers through integration of alfalfa.
• Used biotechnology to improve biomass traits and properties of bioenergy feedstocks.
• Researched the factors responsible for regulating stress tolerance traits that are inherited via seeds or genome imprinting in stock plants.

2. Brief description of the target audience

This planned program is targeted to Tennessee farmers. Secondary audiences include consumers of both basic and applied research (i.e. biofuel industry, food processing companies, and original equipment manufacturers) and the general public.

3. How was eXtension used?

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V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	230	0	330	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	0	44	44

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research-based publications distributed as part of Extension biofuels programs.

Year	Actual
2018	0

Output #2

Output Measure

- Number of underrepresented students trained in bioenergy and climate change research

Year	Actual
2018	0

Output #3

Output Measure

- Develop bio-based agricultural mulches (Hayes)

Year	Actual

2018	1

Output #4

Output Measure

- Increase control of thermal properties of lignin polymers (Chmely)
  Not reporting on this Output for this Annual Report

Output #5

Output Measure

- Produce platform chemicals from hemicellulose (Chmely)
  Not reporting on this Output for this Annual Report

Output #6

Output Measure

- Determine Environmental Fate of Cellulose Nanocrystals (Radosevich)
  Not reporting on this Output for this Annual Report

Output #7

Output Measure

- Provide Process Analytics for Bio-based Products (Young)
  Not reporting on this Output for this Annual Report

Output #8

Output Measure

- Establish nonthermal plasma reaction system (Ye)

Year	Actual
2018	2

Output #9

Output Measure

- Characterize gene expression profile of selected kinase gene families with drought stress (Cheng)

Year	Actual
2018	10

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Address Switchgrass Pathogens and Diseases (Ownley, Zale, Gwinn, Windham)
2	Improve Switchgrass Logistics and Handling (Womac)
3	Develop Lignin-Based Biorefinery Coproducts (Bozell)
4	Use Insects to Help with Biofuel Production (Jurat-Fuentes, Klingeman, Oppert)
5	Deploy Switchgrass Extractives as Bioactive Compounds (Canaday, Gwinn, Labbe, Ownley)
6	Improved understanding of mechanisms of biofuel crop responses to agricultural practices and climate change. (Hui)
7	Improved process-based ecosystem models to forecast biofuel productivity and greenhouse gas emission under future climate conditions. (Hui)
8	Document the growth performance, environmental conditions, and agronomy practices for alternative biomass production in the Southeast. (Illukpitiya)
9	Determine the economic benefits, factors that inhibit adaptation, and cost of short rotation woody biomass crops for bioenergy production. (Illukpitiya)
10	Research to provide insight into factors responsible for regulating stress tolerance traits that are inherited via seeds or genome imprinting in stock plants. (Zhou)
11	Stabilize Bio-oil by Deoxygenation (Chmely)
12	Improve Switchgrass Germination, Yield, and Yield Persistence (Bhandari, Allen)
13	Build and Install the First Synthetic Chloroplast Genome (Liu, Stewart)
14	Optimization of switchgrass biomass and soil respiration via biochar and nitrogen. (Hui)
15	Creating economic opportunities for small and medium sized farmers through integration of alfalfa. (Illukpitiya)
16	Using biotechnology to improve biomass traits and properties of bioenergy feedstocks. (Ondzighi Assoume)
17	Increased understanding of the long-term impact that biodegradable mulches have on the environment (Hayes)

18	Increased understanding of lignin-based advanced carbon materials (Chmely)

Outcome #1

1. **Outcome Measures**

Address Switchgrass Pathogens and Diseases (Ownley, Zale, Gwinn, Windham)

Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

Improve Switchgrass Logistics and Handling (Womac)

Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

Develop Lignin-Based Biorefinery Coproducts (Bozell)

Not Reporting on this Outcome Measure

Outcome #4

1. **Outcome Measures**

Use Insects to Help with Biofuel Production (Jurat-Fuentes, Klingeman, Oppert)

Not Reporting on this Outcome Measure

Outcome #5

1. **Outcome Measures**

Deploy Switchgrass Extractives as Bioactive Compounds (Canaday, Gwinn, Labbe, Ownley)

Not Reporting on this Outcome Measure

Outcome #6

1. **Outcome Measures**

Improved understanding of mechanisms of biofuel crop responses to agricultural practices and climate change. (Hui)

Not Reporting on this Outcome Measure

Outcome #7

1. **Outcome Measures**

Improved process-based ecosystem models to forecast biofuel productivity and greenhouse gas emission under future climate conditions. (Hui)

Not Reporting on this Outcome Measure

Outcome #8

1. **Outcome Measures**

Document the growth performance, environmental conditions, and agronomy practices for alternative biomass production in the Southeast. (Illukpitiya)

2. **Associated Institution Types**

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Small-scale on-farm bioenergy production is relatively new for farmers. Information on reliable crop varieties, field operations and management are essential to attract growers for energy crop farming. This information is needed for long term investment decisions.

What has been done
Field experiments were designed and conducted for 3 varieties of proposed winter oilseed crops (industrial rapeseed, crambe and carinatha). The primary objective was to develop high-throughput reverse-phase high performance liquid chromatography (HPLC) based methods to

characterize and quantify Tryglycerols in oil. Raw oil samples were pre-diluted before analysis. The HPLC-ELSD method was used in this study with some modification for the quantification of Tryglycerols. We completed benefit: costs analysis. Three different processing rates were accounted based on the TSU mobile biodiesel platform. Monte Carlo Simulation was performed to analyze range of net return under varying yield, input prices, and price of seed, biodiesel and seed meal. The stochastic profit function was considered to account the economic risk. We published an extension fact sheet to provide information for stakeholders.

Results

We identified industrial Rapeseed as a potential oilseed feedstock for bioenergy. However multiyear studies are needed to evaluate yield potential before making final recommendations. Carinata and Crambe are susceptible to freezing and snow kill hence need further field trials to identify appropriate planting date and management. The risk analysis shows that net return is sensitive to yield, market price and unit costs of production, there is a potential to make profit from industrial rapeseed if yield can be improved.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management

Outcome #9

1. Outcome Measures

Determine the economic benefits, factors that inhibit adaptation, and cost of short rotation woody biomass crops for bioenergy production. (Illukpitiya)

Not Reporting on this Outcome Measure

Outcome #10

1. Outcome Measures

Research to provide insight into factors responsible for regulating stress tolerance traits that are inherited via seeds or genome imprinting in stock plants. (Zhou)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Root structure is composed of distinct layers of cells in both transverse and vertical directions. Laser-capture microdissection is a technique used to harvest pure cell populations from tissue sections containing a complex ensemble of cells. This project will develop the relevant technology for the isolation of these individual types of cells to develop a workflow to be used for the identification of proteomes/transcriptomes in each individual cell types in tomato plants and develop the first database of proteome expression within these cells. Such information will guide us to precisely select target genes that can be edited or engineered for improving plant performance under suboptimal conditions. The technology developed through this project can be applied to a broad range of plants and other organisms.

What has been done

The project has completed the following goals: 1). development of laser capture microdissection (LCM) procedures for collection of single root cells from Al-treated tomato roots, and switchgrass roots, 2) development of the quantitative proteomics analysis methods for the LCM samples which are in very small amount; 3) completion of TMT proteomics analysis of different layers of root cells in Al-sensitive zones.

Results

The project has established the procedure for single cell type proteomics of plant root cells for resistance to Al and low pH. As a result of this phase of the research by estabolishing the technical procedure, we will be able to conduct single cell proteomics/genomics research projects effectively.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
201	Plant Genome, Genetics, and Genetic Mechanisms

Outcome #11

1. Outcome Measures

Stabilize Bio-oil by Deoxygenation (Chmely)

Not Reporting on this Outcome Measure

Outcome #12

1. Outcome Measures

Improve Switchgrass Germination, Yield, and Yield Persistence (Bhandari, Allen)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done

Results

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms

Outcome #13

1. Outcome Measures

Build and Install the First Synthetic Chloroplast Genome (Liu, Stewart)

Not Reporting on this Outcome Measure

Outcome #14

1. Outcome Measures

Optimization of switchgrass biomass and soil respiration via biochar and nitrogen. (Hui)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
This project improves our understanding how biofuel crops respond to biochar and nutrient applications.

What has been done
In the 2017-2018 project year, we continued field measurements of switchgrass leaf photosynthesis, transpiration, biomass, and soil respiration. We also analyzed data, presented our results at scientific meetings, and wrote manuscripts for publication.

Results
Results showed that while biochar addition and N fertilization did not influence switchgrass leaf photosynthesis and biomass, biochar addition enhanced leaf transpiration, and reduced water use efficiency. Soil respiration was reduced by biochar addition, but significantly enhanced by N fertilization. Biochar and N fertilization interactively influenced soil respiration and seasonal variation of soil respiration was mostly controlled by soil temperature. Results indicated that switchgrass can maintain high productivity without much N input, at least for a few years. The findings from this study are useful to optimize N fertilization and biochar addition in the switchgrass fields for maintaining highly productive switchgrass biomass while reducing soil CO2 emission.

4. Associated Knowledge Areas

KA Code	Knowledge Area
132	Weather and Climate
205	Plant Management Systems

Outcome #15

1. Outcome Measures

Creating economic opportunities for small and medium sized farmers through integration of alfalfa. (Illukpitiya)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Despite the economic and ecological benefits associated with integration of crops such as alfalfa into agricultural production systems, it is not widely produced in the region. This is in part due to limited research and extension work with these crops in the region at the university level. University extension personnel can then use this information to develop outreach approaches for small-scale and minority farmers, including the development of effective publication materials and decision-making tools to help these farmers to gain more knowledge about this crop as a new farming enterprise.

What has been done
A comprehensive survey of literature was done to identify alfalfa based production systems in different regions. We collected production data from alfalfa production regions (mainly western states). We developed a stochastic profit function and based on preliminary data we analyze the profit.

Results
The project is in initial state hence unable to generate meaningful results yet. We have performed only a preliminary analysis so far.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management

Outcome #16

1. Outcome Measures

Using biotechnology to improve biomass traits and properties of bioenergy feedstocks. (Ondzighi Assoume)

2. Associated Institution Types

- 1890 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The main concerns of making liquid fuels used by consumers are the combination of rising oil prices, exhaustion of crude oil reserves, energy insecurity, and environmental pollution. These concerns can be addressed with biofuels used as the replacement for petroleum-based fuels in transportation. Switchgrass is considered as an excellent bioenergy feedstock due to its high biomass yield, wide climatic adaptation, as well as its low energy input for production. Using switchgrass for biofuels necessitates the development of genetic manipulation strategies to produce improved cultivars with better biomass quantity and quality.

What has been done
Tissue culture techniques for switchgrass were developed, and efficient cell culture systems were developed, optimized and established for switchgrass varieties Alamo and Performer. Lignin genes were cloned with CRISPR/Cas9. A reliable stable Agrobacterium tumefaciens-mediated cell suspension cultured transformation was developed and successfully assayed

Results
This work led to the production of efficient cell culture systems capable of genetic transformation in switchgrass varieties Alamo and Performer. It also developed and optimized a regeneration methods for cell systems, and the construction, confirmation, and the use of CRISPR-Cas9 constructs to edit cell wall genes for switchgrass. These results represent an essential improvement regarding the genetic transformation along with the regeneration of the recalcitrant switchgrass. They make a huge difference in term of the efficiency of switchgrass transformation and regeneration when we compare to what it was lastly reported on this crop since 2011.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
511	New and Improved Non-Food Products and Processes

Outcome #17

1. Outcome Measures

Increased understanding of the long-term impact that biodegradable mulches have on the environment (Hayes)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Biodegradable plastic mulches are important tools for sustainable production of specialty crops. However, research is necessary to determine the long-term environmental impacts of these mulches.

What has been done
We have investigated the effect of agricultural weathering on physicochemical properties of biodegradable plastic mulches across 4 successive years and two diverse geographical locations; the impact of agricultural weathering on the biodegradability of biodegradable plastic mulches under ambient soil and industrial composting conditions via standardized laboratory tests; formation of micro- and nano-plastics from plastic mulch films; and understanding the underlying mechanisms of interactions of nanoplastics and soils via small-angle neutron scattering.

Results
Solar radiation is the key determinant of the extent of degradation of plastic mulch films during their deployment. Secondary factors (such as soil moisture and temperature, mulch composition and fabrication, and minor components in air, soil, and water) also play a key role. Agricultural weathering enhances the biodegradability in soil during the initial time course of biodegradation, with the enhancement decreasing with time. In contrast, agricultural weathering plays only a minor role in compostability.

4. Associated Knowledge Areas

KA Code	Knowledge Area
511	New and Improved Non-Food Products and Processes
611	Foreign Policy and Programs

Outcome #18

1. Outcome Measures

Increased understanding of lignin-based advanced carbon materials (Chmely)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Given the effects of climate change and an increasing global security demand, there is a growing need to identify and optimize renewable carbon sources for the development of biochemicals and biofuels. Lignin, an abundant source of renewable carbon, can be converted into valuable materials that are equivalent or even superior to petroleum-based materials.

What has been done
Our research has shown that lignin can be incorporated into existing petroleum-derived hydrogels, which have several applications in the absorption and retention of water (e.g. diapers, contact lenses, seed coatings, etc.).

Results
Lignin incorporation enhances the sustainability of the petroleum-derived hydrogels by using a renewable source of carbon. These new hydrogels outperform their petroleum-derived counterparts regarding water uptake and retention. We believe that these materials can be incorporated into advanced seed coatings that would hold water close to seeds and promote faster germination.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges
- Other (International conflict)

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

• The adaptation of winter oilseed crops has the potential to bring large acreage of land under fallow during winter season that could provide additional revenue for the farmers. The information generated from this research are the products/output from the program.

• Reducing CO2 emissions in biomass production through optimization of the use of biochar and nitrogen.

• Development of new improved regeneration methods for biofuel crops to improve biofuel yields.

• Research to select target genes in roots that can be edited or engineered for improving plant performance under suboptimal conditions. The project has established the procedure for single cell type proteomics of plant root cells for resistance to Al and low pH.

Key Items of Evaluation

VI. National Outcomes and Indicators

1. NIFA Selected Outcomes and Indicators

Childhood Obesity (Outcome 1, Indicator 1.c)	
3886	Number of children and youth who reported eating more of healthy foods.
Climate Change (Outcome 1, Indicator 4)	
0	Number of new crop varieties, animal breeds, and genotypes whit climate adaptive traits.
Global Food Security and Hunger (Outcome 1, Indicator 4.a)	
0	Number of participants adopting best practices and technologies resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources.
Global Food Security and Hunger (Outcome 2, Indicator 1)	
0	Number of new or improved innovations developed for food enterprises.
Food Safety (Outcome 1, Indicator 1)	
0	Number of viable technologies developed or modified for the detection and
Sustainable Energy (Outcome 3, Indicator 2)	
0	Number of farmers who adopted a dedicated bioenergy crop
Sustainable Energy (Outcome 3, Indicator 4)	
0	Tons of feedstocks delivered.