V(A). Planned Program (Summary)

Program # 14

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
101	Appraisal of Soil Resources	0%	0%	4%	
102	Soil, Plant, Water, Nutrient Relationships	0%	0%	7%	
201	Plant Genome, Genetics, and Genetic Mechanisms	0%	0%	14%	
202	Plant Genetic Resources	0%	0%	2%	
205	Plant Management Systems	0%	100%	11%	
206	Basic Plant Biology	0%	0%	6%	
212	Pathogens and Nematodes Affecting Plants	0%	0%	3%	
215	Biological Control of Pests Affecting Plants	0%	0%	2%	
402	Engineering Systems and Equipment	0%	0%	7%	
404	Instrumentation and Control Systems	0%	0%	7%	
501	New and Improved Food Processing Technologies	0%	0%	3%	
511	New and Improved Non-Food Products and Processes	0%	0%	27%	
512	Quality Maintenance in Storing and Marketing Non-Food Products	80%	0%	1%	
601	Economics of Agricultural Production and Farm Management	0%	0%	1%	
603	Market Economics	10%	0%	0%	
605	Natural Resource and Environmental Economics	10%	0%	0%	
607	Consumer Economics	0%	0%	1%	
608	Community Resource Planning and Development	0%	0%	2%	
610	Domestic Policy Analysis	0%	0%	2%	
	Total	100%	100%	100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	4.0	0.5	84.0	0.0
Actual Paid Professional	5.0	0.6	66.0	0.0
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**
80016	25852	649391	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
366706	25852	4839404	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	5291318	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Our economic research is developing national ethanol, biodiesel, electric, and bioproduct demand quantities and incorporating them into an existing dynamic agricultural sector econometric simulation model (POLYSYS). Regional feedstock supply curves necessary to meet national bioenergy and bioproduct demand quantities are being estimated by modifying POLYSYS to include cellulosic feedstock in addition to existing agricultural grain and oilseed crops. Regional bioenergy and bioproduct supply curves are being developed using regional feedstock supply curves, representative transportation costs, and representative costs for each feedstock-technology-product combination considered. A national expansion curve for the bioenergy and bioproduct industry is being estimated. Key indicators of agricultural sector performance including net farm income, agricultural prices, and government cost in meeting national bioenergy and bioproduct demand quantities are being evaluated.

As part of our engineering research, we are documenting drying rates and methods for corn stover, and quantifying the distribution and quality of the above ground biomass.For existing biomass densification systems, we areidentifying relations between particle size, biomass type, final density, compression pressures and energy, and other engineering factors. We are determining optimum particle sizes based on a balance between expended energy, final density, and integrity of compressed pellet or wafer. We are using these optimum particle sizes to identify or invent technologies to achieve the size based on theoretical cutting lengths due to feed speed, cutter speed, and other engineering factors. We are applying the developed technologies in laboratory-scale granulation tests to verify sizes using laser, image analyzer, sieve, and manual methods. We are comparing the developed methods in particle size reduction to existing technologies.

In terms of downstream processing, we are conducting fundamental studies on the fractionation of various free fatty acid (FFA) mixtures to test whether the mathematical modeling approach used by us for rapeseed oil is more widely applicable.Additionally, the food safety of the purified FFA products is being assessed. We will then complete the cost analysis of this fractionation process using results predicted by

the mathematical model using chemical plant design software. A bench-scale continuous reactor is being assembled and we will attempt to maintain the same productivity (moles of product per time per mass of enzyme) as achieved for batch-mode experiments from previous experiments.We are also attempting the further development of microemulsion-based protein extraction as a rapid low-cost and scalable means of selectively isolating and purifying proteins of interest from aqueous media.

Extension agents and specialists in 4 counties as well as Tennessee State University and the Plant Sciences unit reported 470 contacts through 33 group meetings, 16 contacts through 2 on-site visits, 12 contacts from direct mail/telephone calls, and 2 contacts from client visits to the Extension office. In addition, there were 4 exhibits, 10 publications and one radio program that reached 45, 467, and 20,000 contacts, respectively.

2. Brief description of the target audience

This planned program was trageted to Tennessee farmers. Secondary audiences included consumers of both basic and applied research and the general public.

3. How was eXtension used?

The Sustainable Energy planned program was enhanced through the service of five Tennessee Extension professionals on the "Sustainable Ag Energy" CoP. Tennessee Extension personnel shared implementation strategies, outcome measurement, and evaluation protocols with their CoP colleagues.

V(E). Planned Program (Outputs)

1. Standard output measures

2013	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	389	20512	111	0

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

Patent Applications Submitted

Year:	2013
Actual:	7

Patents listed
1. Switchgrass promoter (PvUBI1) and uses thereof (Stewart, Mann)
2. Materials and methods for the production of biodiesel (Chen, Zhao)
3. Methods, systems and devices for simultaneous production of lactic acid and propylene glycol from glycerol (Ye, Liu)
4. Development of a renewable carbon-based bio-modifier for asphalt cement (Huang, Ye, Zhao, Shu)
5. Hydroxide Catalysts for Lignin Depolymerization (Chmely, & ??)
6. Antimicrobial and anti-inflammatory activity of switchgrass-derived extractives (Labbe, Ownley, Gwinn, Moustaid-Moussa, D'Souza)
7. Efficient cobalt-catalyzed oxidative degradation of lignin (Bozell, Biannic)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	11	136	147

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
2013	467

Output #2

Output Measure

- Identify the prevalence of foliar and root diseases of switchgrass in Tennessee and the major fungal pathogens associated with seed (Ownley).
  Not reporting on this Output for this Annual Report

Output #3

Output Measure

- Release improved high yielding synthetic and hybrid varieties of switchgrass. (Bhandari, Allen)
  Not reporting on this Output for this Annual Report

Output #4

Output Measure

- Agricultural mulches formed from biobased poly(lactic acid) and poly(hydroxy alkanoate) blends using Meltblown nonwovens textile technology provide good durability for a 1-3 season duration that is biodegradable under ambient soil environments (Hayes)

Year	Actual
2013	0

Output #5

Output Measure

- Purification of proteins from fermentation broths of agricultural feedstocks at >95% yield has occurred when employing a novel method based on extraction using 3-phase microemulsion systems and pH-degradable surfactants (Hayes)

Year	Actual
2013	0

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Majority of first-pass biomass size reduction done with knife grids or other techology more efficient than rotary (Womac).
2	In-field size reduction and/or compacting done on majority of cellulosic biomass harvested in Tennessee (Womac).
3	Number of growers producing switchgrass as an energy crop. (Jackson)
4	Number of acres of switchgrass grown in Tennessee as an energy crop. (Jackson)
5	Farmer-owned biomass cooperative to help capture economic advantage of bioenergy production (Tiller).
6	Evaluate precision-farming / variable-rate technology for switchgrass and other bioenergy crops (Tyler).
7	Mills using integrated process to produce bioenergy plus enhanced-strength OSB (Wang).
8	Switchgrass pathogens and diseases (Ownley, Zale, Gwinn, Windham)
9	Switchgrass rust control (Windham, Windham)
10	Switchgrass logistics and handling (Womac)
11	Biorefinery coproducts (Bozell)
12	Evaluating the economic impacts of a biorefinery (Larson)
13	Fuel crop effects on soil properties (English, Lee, Tyler)
14	Gene flow in switchgrass and papaya (Kwit)
15	'Green roof' research (Stewart)
16	Impact of cellulosic biofuel industry on the rural economy (Clark, Jensen, Lambert, Yu)
17	Insects to help with biofuel production (Jurat-Fuentes, Klingeman, Oppert)

18	Process analytics of bio-based products (Young)
19	Reduce cost of biomass delivered to biorefinery (English)
20	Switchgrass biomass yield improvement (Bhandari, Allen)
21	Switchgrass extractives as bioactive compounds (Canaday, Gwinn, Labbe, Ownley)
22	Switchgrass storage (English, Larson, Tyler, Yu)

Outcome #1

1. **Outcome Measures**

Majority of first-pass biomass size reduction done with knife grids or other techology more efficient than rotary (Womac).

Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

In-field size reduction and/or compacting done on majority of cellulosic biomass harvested in Tennessee (Womac).

Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

Number of growers producing switchgrass as an energy crop. (Jackson)

Not Reporting on this Outcome Measure

Outcome #4

1. **Outcome Measures**

Number of acres of switchgrass grown in Tennessee as an energy crop. (Jackson)

Not Reporting on this Outcome Measure

Outcome #5

1. **Outcome Measures**

Farmer-owned biomass cooperative to help capture economic advantage of bioenergy production (Tiller).

Not Reporting on this Outcome Measure

Outcome #6

1. **Outcome Measures**

Evaluate precision-farming / variable-rate technology for switchgrass and other bioenergy crops (Tyler).

Not Reporting on this Outcome Measure

Outcome #7

1. **Outcome Measures**

Mills using integrated process to produce bioenergy plus enhanced-strength OSB (Wang).

Not Reporting on this Outcome Measure

Outcome #8

1. **Outcome Measures**

Switchgrass pathogens and diseases (Ownley, Zale, Gwinn, Windham)

2. **Associated Institution Types**

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Identification of switchgrass diseases will enable development of management guidelines to reduce poor stand establishment, to maximize yields for biofuel production, and to reduce negative impacts of fungal pathogens and their toxic metabolites on the biofuel conversion process.

What has been done
We have identified several fungal plant pathogens that can cause significant disease and biomass yield loss in switchgrass.

Results
Most of these pathogens are seedborne, which has led to recommendations for certified seed and seed treatments.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
205	Plant Management Systems
212	Pathogens and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants

Outcome #9

1. Outcome Measures

Switchgrass rust control (Windham, Windham)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Switchgrass rust is one of the most common diseases of switchgrass in fields around Vonore, TN. Switchgrass rust, Puccinia emaculata, reduces growth and biomass of switchgrass in ornamental and agronomic plantings in Tennessee and these epidemics are fueled by asexual spores,

urediospores.

What has been done
A plant has been identified that has superior resistant to ornamental and agronomic strains of rust.

Results
Tests are underway to determine the ornamental qualities of this selection and if the plant can be used as a new variety of switchgrass for agronomic (biofuel) uses.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
212	Pathogens and Nematodes Affecting Plants

Outcome #10

1. Outcome Measures

Switchgrass logistics and handling (Womac)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
As a low-density feedstock, switchgrass size reduction, compaction, and transport are crucial for it to become a successful fuel crop.

What has been done
In order to measure and document improvements, the bulk-format system from field-to-biorefinery was conceived and implemented through a competitive $5M DOE high tonnage logistics grant in cooperation with Genera Energy. GPS tracking of all mobile equipment (5 tractors and 2 semi trucks) was developed in order to identify limiting factors, field efficiency, equipment utilization,

and other indicators of productivity. We oversaw statistical experiments designed to determine capacity and throughput for bulk handling, reclaim, conveyance, and compaction systems.

Results
Data are currently being analyzed for energy use (kWh/DryMg) for reclaim, meter, convey, dust collection, and compaction operations to compare differences due to particle sizes from forage harvester, coarse tub grind, and fine tub grind. These data sets are unique to the biomass industry and are needed by decision makers to determine optimum feedstock supply systems.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment
404	Instrumentation and Control Systems
511	New and Improved Non-Food Products and Processes
601	Economics of Agricultural Production and Farm Management
603	Market Economics
608	Community Resource Planning and Development

Outcome #11

1. Outcome Measures

Biorefinery coproducts (Bozell)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
To be competitive, fuel crops must produce coproducts analogous to those in the petrochemical industry.

What has been done
(1) Lignin is 25% of terrestrial biomass and a key source of renewable carbon, but its structural complexity prevents easy incorporation as a starting material for chemicals or fuels. (2) In contrast

the structure of carbohydrates is regular and understood. However, they possess many sites of very similar reactivity, making it difficult to develop selective conversion processes. (3) The petrochemical industry achieves significant control over their conversion processes because they understand these systems at the molecular level.

Results
Our work (1) is developing selective chemical and biocatalytic systems able to handle this heterogeneity, and has focused on lignin isolation and conversion. (2) exploits catalytic systems able to achieve high selectivity in the presence of functional groups of similar reactivity. (3) pursues analogous control for renewable carbon sources, which provides the ability to tailor processes for eventual end users.

4. Associated Knowledge Areas

KA Code	Knowledge Area
511	New and Improved Non-Food Products and Processes
601	Economics of Agricultural Production and Farm Management

Outcome #12

1. Outcome Measures

Evaluating the economic impacts of a biorefinery (Larson)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Evaluating the economic impacts of a potential biorefinery is a key step in the assessment of the economic, environmental,and social impacts of LCB-based biofuels production on a rural community.

What has been done
A spatially-oriented, mixed integer mathematical programming model was used to evaluate the economic impact of a biorefinery for alternative harvest and storage systems for a 13-county region in East Tennessee.

Results
Results indicated that additional jobs were created in the region. An estimated 1,025 to 1,096 jobs (many are seasonal) were added in agricultural activities. In addition, operation of the biorefinery was expected to increase 60 jobs directly, 324 jobs indirectly, while another 148 were through increased household expenditures.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
603	Market Economics
605	Natural Resource and Environmental Economics
608	Community Resource Planning and Development

Outcome #13

1. Outcome Measures

Fuel crop effects on soil properties (English, Lee, Tyler)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
How does switchgrass change soil properties?

What has been done
One additional year of soil temperature and moisture data were collected. Fuel crop effects on soil: this five-year project is completed.

Results
There was an increase in SOC (especially in deeper soil profile) of roughly 1 Mg ha-1 from 2008 to 2011. The data still support our previous findings: a significant influence on CO2 flux. The summer months exhibited the highest flux rate followed by spring, fall, and finally winter. Many of

the agricultural characteristics of the seven bordering states are represented in Tennessee such as cropping systems, soil type, weather, and farm type and size. Thus, our results found in Tennessee will be applicable in neighboring states as well.

4. Associated Knowledge Areas

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

Outcome #14

1. Outcome Measures

Gene flow in switchgrass and papaya (Kwit)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The molecular documentation of contemporary gene flow is of interest to the conservation biology community, as well as regulators who enforce and set standards for transgene biocontainment.

What has been done
In this area, I assisted colleagues by overseeing work on pollen flow and diagnostic SNP identification in agronomic switchgrass cultivars, as well as methodological refinement for transgene detection in non-transgenic papaya fruits.

Results
The former work will provide the foundation for pollen flow and hybridization potential of switchgrass as a biofuel crop.

4. Associated Knowledge Areas

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

Outcome #15

1. Outcome Measures

'Green roof' research (Stewart)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What has been done
The Low Impact Development Demonstration Area (LIDDA) is a living laboratory, community outreach and outdoor recreational space for visitors, faculty and students.

Results
The installed rain garden and hardscapes have already begun to teach our students the practical application of their studio design courses. Undergraduate students continue to use the LIDDA as a hands-on construction learning area as they design and install various construction components. The LIDDA aids homeowners in incorporating sustainable practices in residential applications. It also serves as the home for UT's first green roof.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
205	Plant Management Systems
404	Instrumentation and Control Systems

608 Community Resource Planning and Development

Outcome #16

1. Outcome Measures

Impact of cellulosic biofuel industry on the rural economy (Clark, Jensen, Lambert, Yu)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The impact of cellulosic biofuel industry on the rural economy is an important question to policy makers of regional development.

What has been done
We applied a GIS model and an input-output framework to determine the potential location of the biofuel industry and its economic impact.

Results
The total economic impact of a 11 mgy cellulosic biofuel industry is considerably less than 1% for changes in employment. If a 11 mgy target is achieved, the change in total value added to the Southeastern region economy is 0.75%. While the relative impacts to the entire economy are modest, over the medium to long run, the cumulative impact of these gains may be substantial.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
603	Market Economics
605	Natural Resource and Environmental Economics
608	Community Resource Planning and Development
610	Domestic Policy Analysis

Outcome #17

1. Outcome Measures

Insects to help with biofuel production (Jurat-Fuentes, Klingeman, Oppert)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Better approaches are needed to metabolize cellulose and lignin for biofuel production from woody materials. Currently used endoglucanases for saccharification of plant biomass in ethanol production have limitations of stability and activity under stringent environments.

What has been done
Insect cellulases work under very stringent environments in the insect gut. We have identified a group of insects with very high cellulolytic activity and performed sequencing of expressed genes to identify highly active enzymes that can be used in efficient degradation of plant biomass.

Results
These enzymes have applications for increasing biofuel production efficiency.

4. Associated Knowledge Areas

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

Outcome #18

1. Outcome Measures

Process analytics of bio-based products (Young)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Wood product producers need to minimize costs and improve quality.

What has been done
The new and emerging biofuels industry could directly benefit from optimization of throughput and improved quality of bioenergy and biofuels from use of a statistical software system that predicts real-time strength properties of manufactured materials.

Results
The corporate training seminars in statistical process control and advanced data mining have documented direct financial benefits to the participating companies ranging from approximately $20,000 to $300,000 per year.

4. Associated Knowledge Areas

KA Code	Knowledge Area
404	Instrumentation and Control Systems
511	New and Improved Non-Food Products and Processes
601	Economics of Agricultural Production and Farm Management
605	Natural Resource and Environmental Economics

Outcome #19

1. Outcome Measures

Reduce cost of biomass delivered to biorefinery (English)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
A lack of knowledge about biomass feedstocks as well as advanced biomass technologies leads to lack of willingness to invest in those technologies and in new crops.

What has been done
A Full Systems Analysis of feedstock production to end-use helps both technology developers and investors identify viable applications of biomass for fuels, power, or products. I have examined the costs of harvest, storage, and transportation of switchgrass.

Results
Our estimates are that a chop, transport, densify, and store system will significantly reduce costs. We are currently evaluating the chemical composition of samples of biomass that we took during storage.

4. Associated Knowledge Areas

KA Code	Knowledge Area
511	New and Improved Non-Food Products and Processes
601	Economics of Agricultural Production and Farm Management
603	Market Economics
605	Natural Resource and Environmental Economics
608	Community Resource Planning and Development

Outcome #20

1. Outcome Measures

Switchgrass biomass yield improvement (Bhandari, Allen)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Development of improved high biomass yielding switchgrass cultivars for use in bioenergy feedstock.

What has been done
The research focuses on enhancing feedstock biomass yield of lowland switchrgass cultivar in Tennessee and the other areas in south eastern regions of USA.

Results
Biomass yield improvement is a primary emphasis of switchgrass cultivar development, which can be achieved by accumulation of additive genes, and/or exploitation of heterosis. The past two years' work has been significant in establishing a strong breeding program in switchgrass. Several plants selected after two years of field evaluation will be directly used in the production of cycle-1 improved experimental varieties. The seed will be available for testing, and superior varieties will be eventually release to growers. Establishment is a major hurdle in switchgrass production, which could be attributable to seed dormancy and small seed size. One cycle of selection for high germination and high seed density from Alamo and Kanlow population is completed, and experimental varieties were produced by intercrossing selected genotypes. Seed is available for field testing in 2014.

4. Associated Knowledge Areas

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

Outcome #21

1. Outcome Measures

Switchgrass extractives as bioactive compounds (Canaday, Gwinn, Labbe, Ownley)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
While the carbohydrate content of switchgrass averages 60-65%, about 10-15% of the dry weight biomass is composed of non-structural compounds (i.e. extractives). This significant fraction contains and/or generates during lignocellulosic biomass pretreatment chemicals that inhibit enzymes and yeasts involved in saccharification and fermentation.

What has been done
We have demonstrated that the extractives contain bioactive components that can be used to protect plants against pathogens as well as modulate immune and inflammatory responses in humans.

Results
Utilizing the extractives portion of switchgrass as a biopesticide and as an anti-inflammatory would add value to this biomass fraction and offer significant opportunities for increasing the sustainability of agriculture.

4. Associated Knowledge Areas

KA Code	Knowledge Area
215	Biological Control of Pests Affecting Plants
605	Natural Resource and Environmental Economics

Outcome #22

1. Outcome Measures

Switchgrass storage (English, Larson, Tyler, Yu)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The quality of biomass feedstock is crucial to the feasibility of bioenergy industry.

What has been done
We continued research to evaluate the effects of alternative outdoor storage methods on the composition of switchgrass that potentially influence biofuel yields. Data from a bale storage experiment at Vonore, TN were used for the study. Switchgrass was sampled for dry matter before baling with the BaleTech III on each harvest date and then at regular intervals to evaluate changes in composition.

Results
Preprocessed switchgrass stored using the BaleTech III system had lower cellulose and higher lignin and ash content than large agricultural round bales. Our findings suggest that sugars available for conversion to ethanol may be lower in switchgrass processed using the BaleTech III system. The outgoing plant-gate break-even prices of ethanol was estimated to be higher with the bale Tech III preprocessing system than with an agricultural round bale system to harvest and store switchgrass.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment
511	New and Improved Non-Food Products and Processes
512	Quality Maintenance in Storing and Marketing Non-Food Products

601 Economics of Agricultural Production and Farm Management

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

An Extension biofuels program was conducted by UT and TSU Extension in five counties with these evalutaion results:

- 154 producers gained the knowledge necessary to determine whether they could profitably produce a decicated energy crop for either on-farm production of renewable energy or for sale to a bio-refinery or other energy producer.
- 154 producers learned about different types of renewable energy options and what renewable energy systems would be technically and economically feasible to operate at the farm level.
- 55 producers learned about the four steps in the process for converting biomass into cellulosic ethanol: preprocessing, pretreatment, hydrolysis, and fermentation and distillation.

Key Items of Evaluation

An Extension biofuels program was conducted by UT and TSU Extension in five counties with these evalutaion results:

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- 55 producers learned about the four steps in the process for converting biomass into cellulosic ethanol: preprocessing, pretreatment, hydrolysis, and fermentation and

distillation.