V(A). Planned Program (Summary)

Program # 9

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
605	Natural Resource and Environmental Economics	100%		100%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	4.0	0.0	2.0	0.0
Actual Paid	4.0	0.0	1.0	0.0
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**
29153	0	59554	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
510861	0	302463	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
8830	0	20121	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Perform experiments to investigate renewable energy production.
- Develop methodologies and scientifically sound alternatives to fossil fuels
- Educate homeowners, business owners, farmers and agri-related businesses, youth and families about conservation and efficiency practices related to energy use.
- Provide education and training to enhance bio energy related job development and careers.

2. Brief description of the target audience

- University faculty, staff and students
- School aged youth
- Families
- Homeowners
- Farmers
- Agri-businesses
- State agencies and organizations
- Industry partners
- Small businesses
- Entrepernuers
- Policy and decision makers

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	129	0	0	0

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

Patent Applications Submitted

Year: 2014

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2014	Extension	Research	Total

Actual	1	3	4

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- -Scientific publications and patents produced -Participants reach through direct and indeirect education -New methodologies and technologies developed

Year	Actual
2014	0

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Short Term - Increase knowledge, energy efficiency technologies and conservation practices related to energy use. Explore research strategies to replace fossil fuel consumption.
2	Medium Term - Participants in direct and indirect educational methods will adopt practices to conserve energy use and reliance on fossil fuels. Business owners will create and maintain green jobs/careers as a result of bioenergy development. Newly developed plants and technologies will be adopted to enhance energy independence.
3	Long Term - Fossil fuel consumption will be replaced with biofuels. Economic development will be enhanced through an increase of jobs and careers as a result of bioenergy development. Environment quality enhanced as a result of sustainable biofuel production and utilization.
4	Integration of Molecular and Classical Perennial Grass Breeding for Turfgrass Improvement and Biofuel Production - Medium Term - Participants in direct and indirect educational methods will adopt practices to conserve energy use and reliance on fossil fuels. Business owners will create and maintain green jobs/careers as a result of bioenergy development. Newly developed plants and technologies will be adopted to enhance energy independence.
5	Improving Estimates from National-scale Above-ground Tree Biomass Equations - Medium Term - Participants in direct and indirect educational methods will adopt practices to conserve energy use and reliance on fossil fuels. Business owners will create and maintain green jobs/careers as a result of bioenergy development. Newly developed plants and technologies will be adopted to enhance energy independence.

Outcome #1

1. **Outcome Measures**

Short Term - Increase knowledge, energy efficiency technologies and conservation practices related to energy use. Explore research strategies to replace fossil fuel consumption.

Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

Medium Term - Participants in direct and indirect educational methods will adopt practices to conserve energy use and reliance on fossil fuels. Business owners will create and maintain green jobs/careers as a result of bioenergy development. Newly developed plants and technologies will be adopted to enhance energy independence.

2. **Associated Institution Types**

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Sustainable Energy Production Using Duckweed Biomass through Optimized Waste-to-Fuel Technologies

The quest for renewable energy alternatives to fossil fuels that have low carbon footprints has become a global priority. In response to the urgent call for significant decreases in Greenhouse Gas (GHG) emission, the Renewable Fuel Standard provision of the Federal Energy Independence and Security Act of 2007 requires 36 billion gallons of biofuels to be used in our nation's transportation fuel supply by the year 2022. Of these, 21 billion gallons are expected to derive from cellulosic and other "second generation (i.e. non-corn starch-based)" biofuels. Two major alternative biofuel strategies are being pursued worldwide. In the so-called second generation biofuels, technologies are being optimized for conversion of cellulosic feedstock materials into sugars for subsequent fermentation. However, cellulose is heavily fortified in plant-

based feedstocks and requires significant energy input and enzyme pretreatments to aid its transformation into fermentable sugars with current technologies. With current estimated production cost of cellulosic ethanol at about 3 times that of corn-starch ethanol, it is unclear if and when cellulosic bioethanol will become economically viable. The situation with algal biodiesel, also called third generation biofuel, is perhaps even a bit worse since the scale-up of this approach has been particularly problematic. One of the major issues, for example, is the economical separation of algal biomass from the aqueous medium in which it has been growing. A recent life cycle analyses of these different biofuel feedstocks have raised significant concerns over their true environmental impact, especially for algal biofuels. Alternative sources of renewable biomass are needed. NJAES researchers are exploring the potential for using the Lemnaceae family of aquatic plants, commonly called duckweeds, as a commercially viable feedstock as a micro-crop for fuel production. Duckweeds are flowering aquatic plants which float on or just beneath the surface of still or slow-moving bodies of fresh water and wetlands. The chief characteristics that make duckweeds ideal for waste-to-energy conversion are their rapid growth rate, easy harvesting potential, and ability to grow directly on existing wastewater sites.

What has been done

NJAES researchers seek to develop new aquatic agronomic methods for deploying selected duckweed strains as a waste-to-fuel platforms. Identifying optimal strains for biomass production from municipal wastewater and creating a sustainable wastewater-to-fuel pipeline for this process are the first steps in this research. To facilitate the creation of a new aquatic cropping system with duckweed, these researchers have also focused on developing the biotechnology that will pave the way toward breeding elite duckweed strains with desirable traits, such as high growth rate duckweed strains that also can accumulate high concentrations of target components such as starch (for bioethanol production) or protein (for animal feed).

Results

NJAES researchers have identified a number of duckweed strains that can grow well in municipal wastewater and those that can produce high starch or protein, and have partnered with a start-up company in Argentina to implement this process. These researchers have now completed the first database for two molecular barcodes with data from all 37 known species of duckweed. This resource can now be deployed to identify 30 out of the 37 species within 3 days via a generic PCR-based protocol. This work should help duckweed researchers and application specialists in more accurate typing of duckweed isolates worldwide. To help advance genomic approaches in duckweed, a highly accurate genome sequence map is essential. Toward this end, NJAES researchers are finalizing work in de novo genome sequencing and assembly for a strain of Greater Duckweed, S. polyrhiza (9509). Using a novel integration approach with genome draft sequence of another strain of S. polyrhiza (7498), they have produced a high fidelity reference genome for this species of duckweed and have validated its genome assembly as well as the predicted transcript models. This work should help set the stage for genomics-guide breeding of duckweeds in the near future. This research can potentially play a major role in getting this new crop system adapted and perhaps spark a new source of renewable fuel in the near future. The success of this project will have local impact in New Jersey and elsewhere in the U.S., as well as internationally, by creating a new industry for the agronomic deployment of duckweed micro-crops.

4. Associated Knowledge Areas

KA Code	Knowledge Area
605	Natural Resource and Environmental Economics

Outcome #3

1. Outcome Measures

Long Term - Fossil fuel consumption will be replaced with biofuels. Economic development will be enhanced through an increase of jobs and careers as a result of bioenergy development. Environment quality enhanced as a result of sustainable biofuel production and utilization.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Horticultural Engineering

Controlled environment plant production systems (greenhouses and growth chambers) are used worldwide to produce high quality plant material (produce, floriculture, and nursery crops). Rising energy prices have made a significant impact on the profitability of many greenhouse operations. Engineering information and solutions can help growers reduce energy use and operating costs. Alternative energy sources and novel technologies need to be investigated for potential applicability and economic return. Some of the technologies involved require relatively high initial investment costs. Therefore, research is needed to determine the best possible applications before growers are able to make informed investment decisions. Education outreach efforts are necessary to reach target audiences.

What has been done
Two projects are ongoing that are related to greenhouse energy efficiency. Both projects are collaborations with several other educational institutions from across the country. One of the projects investigates the use of light emitting diode (LED) lighting systems for photoperiodic and supplemental lighting of vegetable and flowering crops. The other project aims to develop an online (undergraduate) course consisting of individual lectures (modules) focused on engineering and crop production issues that can be integrated into a variety of courses related to controlled environment plant production.

Results

Greenhouse energy use research has resulted in new information that has been communicated with the industry through presentations and webinars. Growers who implemented the information resulting from research and presentations have been able to realize energy savings between 5 and 30%. Several course modules on horticultural engineering topics were developed and made available as webinars as part of our multi-institutional education project. A project stakeholder meeting organized at Rutgers provided valuable information for our research project on the use of LED lighting systems for horticultural applications.

4. Associated Knowledge Areas

KA Code	Knowledge Area
605	Natural Resource and Environmental Economics

Outcome #4

1. Outcome Measures

Integration of Molecular and Classical Perennial Grass Breeding for Turfgrass Improvement and Biofuel Production - Medium Term - Participants in direct and indirect educational methods will adopt practices to conserve energy use and reliance on fossil fuels. Business owners will create and maintain green jobs/careers as a result of bioenergy development. Newly developed plants and technologies will be adopted to enhance energy independence.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Integration of Molecular and Classical Perennial Grass Breeding for Turfgrass Improvement and Biofuel Production

Although perennial grasses such as switchgrasses are expected to be used as a biofuel crop on marginal land, there has been little to no extensive research to evaluate their performance on marginal land. Therefore, it is unknown how perennial grasses will perform on marginal land and how different soil types influence yield characteristics such as cellulose and lignin content, plant height, disease, drought etc. This knowledge is critical to the successful development of biofuels

so that enough biomass can be generated domestically to offset foreign oil dependency. Marginal cropland typically has poor quality soils with low amounts of N (nitrogen) which can reduce biomass yield. Like turfgrasses, switchgrass is not a food crop and until recently has not been widely studied at the genomic level. In order for switchgrass and other perennial grasses to be successful and economical for biofuel production on marginal land we need to understand the mechanisms of stress tolerance, i.e. response to Nitrogen, Phosphorous, drought, and how environmental conditions like marginal land influence cellulose and lignin content in plant tissue.

What has been done
NJAES researchers are using laboratory methods and field trials: to identify proper selection procedures to optimize selection of germplasm for biomass production on marginal land with limited nitrogen; to identify, clones and cultivars that respond positively to added nitrogen and which produce high biomass yields in marginal land with low amounts of N; to identify superior clones and/or families to use in population improvement programs to develop new cultivars with better performance on marginal land; and to identify optimum breeding and selection techniques. Genomic approaches are used to identify the best performing switchgrass plants on marginal land (with low N) in Northeastern US and identify germplasm with improved performance on marginal land to use in a breeding program.

Results
Several studies were planted in previous years on prime and marginal sites to identify the best selection procedures for the identification of germplasm with improved performance on marginal land. With USDA-NIFA funding, this research has identified 22 clones of switchgrass with both high yields on reclaimed mine land and high yield in prime soil. The next steps here are to recombine these selections and use population improvement to concentrate genes important for high biomass yield in marginal environments. This line of research is unique in that it specifically provides strategies for integrating feedstock production onto marginal land, which will be critical to the enhancement of our economy and critical to the increased use of biomass fuel sources. This research will improve the current state of knowledge of biomass yield of perennial grasses on marginal land and will provide a crucial step in the implementation of perennial grass biomass production in stressful environments.

4. Associated Knowledge Areas

KA Code	Knowledge Area
605	Natural Resource and Environmental Economics

<u>Outcome #5</u>

1. Outcome Measures

Improving Estimates from National-scale Above-ground Tree Biomass Equations - Medium Term - Participants in direct and indirect educational methods will adopt practices to conserve energy use and reliance on fossil fuels. Business owners will create and maintain green jobs/careers as a result of bioenergy development. Newly developed plants and technologies will be adopted to enhance energy independence.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Improving Estimates from National-scale Above-ground Tree Biomass Equations

Concern over global climate change has led to intense interest in carbon accounting. Forests play a major role in the carbon cycle by sequestering carbon in cellulose (e.g., Malmsheimer et al. 2008). Determining the amount of carbon stored in a forest is a daunting task yet is essential for reliable carbon accounting.

What has been done
NJAES research concentrate on improving estimation of
above-ground biomass (and consequently, improved estimates of carbon storage) in forest trees. The USDA Forest Service has produced a comprehensive, national-scale set of biomass equations for all tree species in the United States (Jenkins et al. 2003). These equations were developed from meta-analysis of "pseudodata" generated from a comprehensive list of published volume equations. As a result, the equations are almost certainly biased for specific species, and it is not possible to generate valid confidence intervals for predictions from the equations.

Results
This work led to more accurate estimation of carbon biomass stored in forests. Perhaps more importantly, it will permit computation of valid uncertainty estimates for estimates which use the Jenkins et al. equations. As stated in chapter 6 of IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (http://www.ipccnggip.iges.or.jp/public/gp/english/), it is essential to be able to quantify the level of uncertainty in estimates of carbon storage. Better estimates of carbon storage is needed to design national forest management schemes aimed at enhancing the role of forests as carbon sinks and ameliorating the effects of global climate change, and also for determining the value of forests in carbon markets such as the Chicago Climate Exchange. In order to assess the total error in biomass prediction, data needed to fit an individual tree biomass model, and another data set consisting of a large mapped stand in which inventories could be simulated and simulation results compared against the actual, known biomass of the stand (possible only with a fully mapped stand). Due to data scarcity issues, green weight was used instead of biomass. It showed that the common practice of ignoring model parameter uncertainty in weight prediction results in confidence intervals which are far too liberal, underestimating uncertainty by 10-40%. I

common practice of ignoring log transformation bias introduced large and non-ignorable bias in weight prediction.

4. Associated Knowledge Areas

KA Code	Knowledge Area
605	Natural Resource and Environmental Economics

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Other (Consumption Practices)

Brief Explanation

None to report.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

NJAES research and extension outcomes related to this planned program were evaluated utilizing a variety of evaluation methods appropriate for each initiative to determine effectiveness on both a qualitative and quantitative level. For KASA and practice change we included the measurement of knowledge gained as measured by pre/post Likert-scale assessments. Surveys were used to measure increase in skills acquired, behavior change and practice adoption. For process evaluation we focused on program delivery, participation, relevance and timeliness. Data was collected at appropriate times for each initiative that supports this planned program. IRB approved evaluation instruments were used to collect research and extension data. Data analyses and comparisons relevant to basic and applied research and demonstration were collected and analyzed and reported utilizing a variety of data collection methods appropriate to each research question. The major goal of evaluating is the demonstration of social, economic, behavior and environmental changes in conditions that contribute to improved quality of life as a result of participation in programs and benefits of research solutions. See state defined outcomes for detailed results of each initiative.

Key Items of Evaluation

None to report.