V(A). Planned Program (Summary)

Program # 3

1. Name of the Planned Program

Sustainable Energy

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
123	Management and Sustainability of Forest Resources			52%	
201	Plant Genome, Genetics, and Genetic Mechanisms			11%	
206	Basic Plant Biology			4%	
402	Engineering Systems and Equipment			26%	
605	Natural Resource and Environmental Economics			3%	
609	Economic Theory and Methods			4%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2011	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	1.8	0.0
Actual Paid Professional	0.0	0.0	2.9	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**
0	0	76915	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	215133	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	358526	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Conduct scientific research projects. Publish peer-reviewed journal articles and other publications. Present findings at professional and public meetings and at other venues. Educate undergraduate and graduate students.

2. Brief description of the target audience

Maine forest resources industry, other scientists, Cooperative Extension staff, state and federal policymakers, regulators, and legislators, classroom teachers

3. How was eXtension used?

{No Data Entered}

V(E). Planned Program (Outputs)

1. Standard output measures

2011	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	0	0	0	0

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

Patent Applications Submitted

Year: 2011

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2011	Extension	Research	Total
Actual	0	5	5

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of other publications

Year	Actual
2011	0

Output #2

Output Measure

- Number of research projects completed

Year	Actual
2011	3

Output #3

Output Measure

- Number of professional presentations

Year	Actual
2011	8

Output #4

Output Measure

- Outreach to K-12 teachers to promote education on photosynthesis-related topics, focusing on the sea slug system.

Year	Actual
2011	0

Output #5

Output Measure

- A hands-on teaching/recruiting experience using sea slug and algal feeding experiments.

Year	Actual
2011	0

Output #6

Output Measure

- A new transcriptome database for Elysia chlorotica, using high-throughput sequencing.

Year	Actual

2011	0

Output #7

Output Measure

- Initial database for forest-based bioethanol and "drop-in" biofuels

Year	Actual
2011	0

Output #8

Output Measure

- Ongoing modification of Tool for Sustainability Impact Assessment (ToSIA)

Year	Actual
2011	0

Output #9

Output Measure

- An integrated sustainability assessment framework for forest based products

Year	Actual
2011	0

Output #10

Output Measure

- A spectral database of a mixture of spectral images of woody biomass was created

Year	Actual
2011	0

Output #11

Output Measure

- $ amount of extramural funding received by faculty in this program area

Year	Actual
2011	506178

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Develop in-process-line, real-time sensor components that incorporate NIRS information for process control and decision-making in woody biomass process stream
2	Development of products of value for use as bio-based fuel from the basic components of lignocellulosic materials
3	Novel wood adhesives containing the solid residues of biomass fermentation from biofuels/biochemical research that reduce or eliminate the use of petrochemical-based adhesive systems
4	Better understanding of synthetic photosynthesis as it relates to alternatives to biofuel production
5	Develop statistical classification models to predict the chemical characteristics and processing quality of woody biomass
6	Improve collaboration across disciplines and institutions to successfully conduct research focused on bio-oil and food supplement production from microalgae grown on low-cost lignocellulosic sugars

Outcome #1

1. **Outcome Measures**

   Develop in-process-line, real-time sensor components that incorporate NIRS information for process control and decision-making in woody biomass process stream

   Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

   Development of products of value for use as bio-based fuel from the basic components of lignocellulosic materials

   Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

   Novel wood adhesives containing the solid residues of biomass fermentation from biofuels/biochemical research that reduce or eliminate the use of petrochemical-based adhesive systems

   Not Reporting on this Outcome Measure

Outcome #4

1. **Outcome Measures**

   Better understanding of synthetic photosynthesis as it relates to alternatives to biofuel production

2. **Associated Institution Types**

   - 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2011	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Photosynthesis is the primary determinant of crop productivity. Photosynthesis and the formation of food, fiber, and biomass are dramatically limited by environmental, biochemical, and genetic constraints. Alleviation of some or all of these constraints could lead to substantial increases in plant productivity.

What has been done
Scientists at the University of Maine developed a culture system for rearing sea slugs in the laboratory and establishing the symbiotic association using laboratory-cultured algal prey, Vaucheria litorea. PCR and qRT-PCR were also used to examine for presence and expression of 11 genes for algal nuclear encoded chloroplast proteins in individual animals over a feeding time course.

Results
The scientists determined that the plastid association in Elysia chlorotica (sea slug) is reversible for the first 6 to 7 days and thereafter, becomes permanent. In their search for examples of gene transfer from the algal prey to the sea slug, they employed 454 pyrosequencing to generate 148 Mbp of cDNA sequence data from actively photosynthesizing adult sea slugs. This approach identified 20 ESTs of potential foreign origin and several plastid-derived transcripts primarily from V. litorea, indicating plastid activity. None of these 20 ESTs, however, have a direct involvement in photosynthesis. The researchers are communicating with Carolina Biological about the possibility of technology transfer related to our ability to rear the sea slugs in the laboratory and their potential for development as a teaching tool.

4. Associated Knowledge Areas

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

Outcome #5

1. Outcome Measures

Develop statistical classification models to predict the chemical characteristics and processing quality of woody biomass

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2011	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Maine? forest bioproducts industry needs rapid near real-time capabilities using in-process-line sensors to replace slower off-line methods. A first step to developing these sensors is a better understanding of the basic chemical structure of woody biomass through capturing of near-infrared spectra. These data will be used to create an information system that will identify extracts with the highest probability of moving to developing co-product markets. Near-infrared methods will increase the speed with which the woody biomass output stream can be analyzed, saving time and money.

What has been done
MAFES researchers have created a spectral database of a mixture of spectral images. This database was created with the assistance of project collaborators in the Forest Bioproducts Research Institute as well as project industrial collaborators, Old Town Fuel and Fiber.

Results
The nearly 2100 individual spectral images characterize the component chemical compounds in woody biomass extracts that are potentially economically viable pulp and paper co-products for biofuels and biochemicals. The researchers have developed preliminary statistical and chemometric models that illustrate accurate determination for sugar concentration. Other chemicals (such as ligins and xylans) that may complex with the sugars and reduce the ability to convert to viable market co-products were also identified through chemometric modeling but at a much lower accuracy (90% r-coefficient). These outputs have been disseminated through the auspices of the Forest Bioproducts Research Institute during stakeholder meetings.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment

Outcome #6

1. Outcome Measures

Improve collaboration across disciplines and institutions to successfully conduct research focused on bio-oil and food supplement production from microalgae grown on low-cost lignocellulosic sugars

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual

2011	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

In regions of the US where sunlight is limited and the traditional wood products industry is in decline, there is a need to develop alternative feedstocks and novel technologies to support bio-fuel production. The growth of algal biomass for sustainable bioenergy has fewer ecological and social costs compared to the use of higher plants grown on land. Algal bio-oil has been identified as a key replacement for petroleum-based diesel as it requires no substantial modification to existing infrastructure. Autotrophic growth of algal biomass for bio-oil production has low biomass productivity and geological limitations. The advantages of heterotrophic and mixotrophic growth of algae for bio-oil production include increased lipid productivity and the ease of scale-up. However, scientific and technological supports are lacking and additional research is needed to overcome bottleneck issues.

What has been done

Researchers from the University of Maine and the Bigelow Laboratory for Ocean Sciences have formed a team of scientists with expertise in biomaterials science, biology, food science and nutrition, marine sciences/analytic chemistry, economics and marine algae and phytoplankton. Scientists at the Bigelow Laboratory for Ocean Sciences have identified one diatom, Cyclotella cryptica, for bio-oil production. The growth conditions of the diatom and Chlorella protothecoides grown on cellulosic sugars have been optimized in the laboratory of University of Maine for maximum biomass production. An analyzing method had been developed for fast test of the lipid content of algae.

Results

The collaborations have been expanded to additional partners. In addition to scientists from other universities and research labs, partnerships have also been successfully established with industry including Solazyme, Inc., FMC Corporation, LP Building Products, and Technological Innovations, LLC. A general agreement has been reached among all of the organizations that to use the cellulosic residues from wood products industry as a sugars source for heterotrophic growth of algae was a viable approach for sustainable production of boi-oil, value-added structural building products, and food supplements. The researchers also involved the Passamaquoddy Tribe in Maine for potential partnership on development of sustainable bioenergy for the tribal community through implanting the heterotrophic growth technology into their existing algal-growing facility. This established network will facilitate future collaborations on sustainable bioenergy production.

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources
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

Brief Explanation

{No Data Entered}

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Evaluations are currently conducted at the project and program levels.

At the project level, all projects are reviewed by an internal research council and external peer reviewers when initiated and again at completion by the research council. During the research council final evaluation, the focus is on determining if terminating projects met their stated objectives, secured extramural funding, and produced peer-reviewed publications. For FY11, no projects went through the review process in this program area. As for other measures of successful research programs, faculty in this program area published 5 peer-reviewed articles and secured $506,178 in extramural funding. Furthermore, in FY11 research published by faculty in this program area was cited by peers more than 120 times in other peer-reviewed journals. Additionally, the researchers using sea slugs to develop a better understanding of photosynthesis have been communicating with Carolina Biological about the possibility of technology transfer related to the their ability to rear the sea slugs in the laboratory and the potential for development for using sea slugs as a teaching tool, thereby extending experiment station research into high school and college science classrooms.

Researchers use a variety of methods to evaluate their own research projects including evaluations retrospectively, before-after, and during the life of the project; case studies; and comparisons between treatment/intervention and nontreatment/nonintervention.

At the program level, external NIFA review teams are asked to review the research programs of schools/departments. These teams provide input on the impact and productivity of research programs supported through the station. The station is working to develop a standard program-level evaluation process, which will be used to evaluate each station program area. Our current plans include an approach based on use of expert panels as recommended by the federal Government Accounting Office with individual program evaluations occurring every four to five years on a staggered time table.

Key Items of Evaluation

The success of a research program can be evaluated in many ways. One such method involves extending techniques developed in the project for educational use. UMaine researchers using sea slugs to develop a better understanding of photosynthesis have been communicating with Carolina Biological about the possibility of technology transfer related to the their ability to rear the sea slugs in the laboratory and the potential for using sea slugs as a teaching tool in high school and college science classrooms. These researchers have been working with several high schools in Maine, and the PI was the recipient of a UMaine Center for Excellence in Teaching and Assessment Active Learning Grant with her post-doctoral associate this past year entitled, "Science in minutes: Using a community-based contributory research project as a dual recruitment and learning tool."