V(A). Planned Program (Summary)

Program # 1

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%		5%	
102	Soil, Plant, Water, Nutrient Relationships	0%		15%	
111	Conservation and Efficient Use of Water	0%		15%	
112	Watershed Protection and Management	0%		5%	
125	Agroforestry	7%		5%	
132	Weather and Climate	0%		5%	
133	Pollution Prevention and Mitigation	0%		5%	
402	Engineering Systems and Equipment	20%		5%	
403	Waste Disposal, Recycling, and Reuse	7%		10%	
404	Instrumentation and Control Systems	0%		5%	
405	Drainage and Irrigation Systems and Facilities	0%		5%	
511	New and Improved Non-Food Products and Processes	21%		5%	
601	Economics of Agricultural Production and Farm Management	8%		10%	
608	Community Resource Planning and Development	7%		3%	
609	Economic Theory and Methods	17%		2%	
903	Communication, Education, and Information Delivery	13%		0%	
	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	6.0	0.0	6.0	0.0

Actual Paid	2.3	0.0	6.0	0.0
Actual Volunteer	31.0	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**
38987	0	421046	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
38987	0	2742558	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
76032	0	2128333	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

In summary:
- Conduct basic and applied research
- Develop models and simulation tools
- Develop new culture strains and metabolic engineering tools
- Develop energy saving techniques and recycling of green waste
- Develop products, resources
- Conduct surveys and assessments
- Conduct data analyses
- Conduct workshops
- Lead short course and training seminars
- Provide training
- Partner and engage with community and environmental organizations
- Contribute to trade and peer reviewed journal publications

2. Brief description of the target audience

The target audiences are:

- public sector
- private sector
- economists
- policy makers
- agricultural biotechnology firms
- farmers and agricultural managers

- livestock growers and managers
- energy (including bioenergy/biofuel, hydrogen and fuel cells) industry,
- forest owners and managers
- research community at large
- environmental organizations
- community members

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	1467	2946	105	562

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	11	12

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Conference Presentations

Year	Actual
2014	14

Output #2

Output Measure

- Number of Courses Developed that include the Planned Program and State Defined Outcomes as part of the curriculum

Year	Actual
2014	0

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Improved knowledge about composition and conversion of feedstocks for biofuels, bioenergy, and bioproducts, including co-products (number of new technologies developed, feedstocks (crops or organisms) investigated, residues or invasive species addressed)
2	Improved agricultural or engineering applications to advance production systems for bioenergy, e.g., a) new technologies, such as improved water use and quality, optimized photobiological processes to yield higher energy efficiencies, use of waste biomass (such as animal wastes and the organic component of urban wastewater) as feedstock to yield bioenergy and reduce waste and pollution sources, b) improved feedstock logistics c) resource inputs, outputs and quality
3	Models developed to look at biofuel and bioenergy productivity, technological processes, sustainability, and supply chain (numbers of decision tools, economic and life cycle analyses, productivity analyses)
4	Enhanced or improved bioeconomy (analyses of the number of new jobs, increased revenues, gallons of biofuels produced or consumed, gallons of fossil fuel displaced), numbers of farms involved in feedstock production)
5	Increased knowledge regarding the use of agricultural crops for energy production (percent increase in knoweldge of attendees to workshops, field days and demonstrations)
6	Improved sustainability of alternative energy supply chain, including evaluations of land use changes, biodiversity, acreages and tonnage of feedstocks produced and used, distributed conversion and processing,
7	Increased knowledge regarding the use of forest biomass as an energy source (Percentage increase in knowledge of attendees to workshops, field days, and demonstrations)
8	Increased knowledge of wave energy, particularly by coastal stakeholders (Percent increase in knowledge of attendees to workshops, field days, and demonstrations)

Outcome #1

1. Outcome Measures

Improved knowledge about composition and conversion of feedstocks for biofuels, bioenergy, and bioproducts, including co-products (number of new technologies developed, feedstocks (crops or organisms) investigated, residues or invasive species addressed)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
For biomass to become economically feasible as a substitute for fossil fuels, conversion of the biomass and and improved knowledge of the biomass must be improved. The identification of cheaper catalysts as well as utilization of the many components of biomass as other products will improve the value chain

What has been done
Substantial progress has been made in the utilization of agricultural residues, forest residues, invasive species, and purposely grown energy crops for biopower and as a substitute for fossil fuels. This includes the successful torrefaction of and test burns of the torrified material in a coal boiler, successful pyrolysis of juniper to bio-oil and gasification through wet torrefaction of dairy manure to produce energy for dairy farms.

Results
Agronomic studies of Arundo donax as a biopower crop and as a rotation crop for onions, potatoes, corn, and alfalfa in the Columbia River Basin have been completed. Arundo has the ability to provide 30 bdt/ac and torrefied Arundo has a much higher btu content and lower moisture content the PBR coal. The study also confirmed that the invasiveness of Arundo in the CRB is minimal and it is readily controlled through good agricultural practices.

A portable pyrolysis device has been tested on Western Juniper and Pinyon Pine and both materials produce a pyrolysis oil that is readily upgraded to HC fuels

Lignin produced as a byproduct of cellulosic ethanol production can be converted to valuable intermediate chemicals and is an economical source of hydrogen for upgrading alcohol to jet fuels.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
125	Agroforestry
132	Weather and Climate
133	Pollution Prevention and Mitigation
402	Engineering Systems and Equipment
403	Waste Disposal, Recycling, and Reuse
404	Instrumentation and Control Systems
511	New and Improved Non-Food Products and Processes
601	Economics of Agricultural Production and Farm Management
608	Community Resource Planning and Development
609	Economic Theory and Methods
903	Communication, Education, and Information Delivery

Outcome #2

1. Outcome Measures

Improved agricultural or engineering applications to advance production systems for bioenergy, e.g., a) new technologies, such as improved water use and quality, optimized photobiological processes to yield higher energy efficiencies, use of waste biomass (such as animal wastes and the organic component of urban wastewater) as feedstock to yield bioenergy and reduce waste and pollution sources, b) improved feedstock logistics c) resource inputs, outputs and quality

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Animal wastes from confined feeding operations and dairies are an important source of surface water and groundwater contamination. Elimination or repurposing of these waste streams improves environmental conditions and can improve operational economics

What has been done
Dairy wastes were subjected to two different treatments: torrefaction and subsequent gasification of the wet waste to produce gas for driving electrical generators and to produce biochar for soil amendments, and the dairy effluent was treated with algae ponds to produce a nutrient rich replacement for peat for the ornamental industry.

Results
A rotary torrefier has been successfully tested to convert wet dairy waste to methane gas and biochar. This process has several advantages over anaerobic digestion in terms of waste handling and infrastructure costs.

Algae have been successfully deployed to treat effluents from dairies with two product streams; water that is sufficiently cleaned for reuse and the resultant dried algae biomass shows considerable promise as a substitute for peat moss. This provides an additional revenue stream for the dairy and has the environmental benefits of reducing dairy waste impacts on surface water and groundwater and significantly reducing the harvest of peat in very sensitive habitats.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
102	Soil, Plant, Water, Nutrient Relationships
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
125	Agroforestry
133	Pollution Prevention and Mitigation
402	Engineering Systems and Equipment
403	Waste Disposal, Recycling, and Reuse
405	Drainage and Irrigation Systems and Facilities
511	New and Improved Non-Food Products and Processes
601	Economics of Agricultural Production and Farm Management
608	Community Resource Planning and Development
609	Economic Theory and Methods
903	Communication, Education, and Information Delivery

Outcome #3

1. Outcome Measures

Models developed to look at biofuel and bioenergy productivity, technological processes, sustainability, and supply chain (numbers of decision tools, economic and life cycle analyses, productivity analyses)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Camelina has been proposed as a possible bioenergy crop to be grown in rotation with dry land wheat. Jet fuel from camelina has been tested and certified by DOD and many airlines. However, only 50,000 acres of camelina has been planted across the US suggesting a general equilibrium model could show issues within the supply chain that would benefit from market interventions.

What has been done
A general equilibrium model was developed that simultaneously accounts for a number of different sectors key to the problem analysis. Parameters were calibrated primarily using a highly detailed IMPLAN data for the PNW and the rest of the United States. The study explicitly models the separate stages of a vertical supply chain, including sourcing from inside and outside a region of the US, and from abroad as well.

Results
Supply chain costs place the cost of biojet fuel derived from camelina at a disadvantage when compared to petroleum based jet fuel. The most realistic scenario to make biojet competitive with petroleum based jet fuel would involve providing a 9% subsidy for biojet and a 9% tax on conventional fuels. This mitigates the gap between the fuel prices and is approximately revenue neutral for government. It is less likely to induce distortions in markets beyond those of central interest to this study.

4. Associated Knowledge Areas

KA Code	Knowledge Area
125	Agroforestry
133	Pollution Prevention and Mitigation
402	Engineering Systems and Equipment
511	New and Improved Non-Food Products and Processes
601	Economics of Agricultural Production and Farm Management
609	Economic Theory and Methods

Outcome #4

1. Outcome Measures

Enhanced or improved bioeconomy (analyses of the number of new jobs, increased revenues, gallons of biofuels produced or consumed, gallons of fossil fuel displaced), numbers of farms involved in feedstock production)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	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
125	Agroforestry
402	Engineering Systems and Equipment
511	New and Improved Non-Food Products and Processes
601	Economics of Agricultural Production and Farm Management
608	Community Resource Planning and Development
903	Communication, Education, and Information Delivery

Outcome #5

1. Outcome Measures

Increased knowledge regarding the use of agricultural crops for energy production (percent increase in knoweldge of attendees to workshops, field days and demonstrations)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Several energy crops including canola, camelina, and Arundo donax are being considered as potential feedstocks for biofuels and biopower. Agricultural producers lack sufficient information to adopt these crops as part of their existing production plans.

What has been done
Enterprise budget using AgTools are being developed for Arundo and an Experiment Station Bulletin is being prepared on Arundo agronomics. A general equilibrium model has been built for camelina supply chain production and this is readily adaptable to canola.

Results
Future workshops are planned for growers in the CBR to improve knowledge of these important crops.

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
402	Engineering Systems and Equipment
511	New and Improved Non-Food Products and Processes
601	Economics of Agricultural Production and Farm Management
608	Community Resource Planning and Development
903	Communication, Education, and Information Delivery

Outcome #6

1. Outcome Measures

Improved sustainability of alternative energy supply chain, including evaluations of land use changes, biodiversity, acreages and tonnage of feedstocks produced and used, distributed conversion and processing,

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
In order for people to embrace alternative energy, there must be assurances that production of that energy is sustainable, particularly in terms of water usage. Work to date has evaluated improved irrigation efficiencies and the impact of renewable energy on crop production.

What has been done
Field experiments analyzing crop production responses, including methods that help reduce irigation water demand in various crops.

Major analysis is underway to determine the effects of wind turbines on Irrigated agriculture. Current status is the development of data analysis algorithms. Large Eddy simulations have been performed in conjunction with collaborators at the University of Utah to determine the synergistic effects of wind turbines and field patch size on evaporation. A manuscript in under review of this work.
Additional activities involved: 1. Developed DNDC models for assessing the sensitivity of the emissions to the variation in agricultural practices, weather and nitrogen fertilizer use during production of camelina in Pacific Northwest (specifically Pendleton Region). 2. Developed life cycle assessment models in OpenLCA software for camelina production in Pacific Northwest. 3. Completed development of Global Bioenergy Partnership (GBEP) Metrics in OpenLCA.

Results
Above activities resulted in the following outputs: 1. Models for assessing the impact of agricultural practices and weather on the emissions relevant for life cycle assessment during crop production. 2. Life Cycle Assessment models for Camelina production. 3. Life Cycle Impact Assessment models for incorporating GBEP metrics. A UAV was used in conjunction with fiber optic distributed temperature sensing technology to form the basis for a field measurement campaign in September 2014. The data collected will be used to test multiple hypotheses, including the impact of the wind turbine on local mixing processes within a turbine wake. Analysis is complete for the first manuscript, to be submitted 1st quarter, 2015. A secondary experiment of opportunity was installed at no cost to the project. We recognized that the recent solar array at Rabbit Field provided an excellent opportunity to extend our hypotheses. To this end, a longer-term monitoring effort was installed to measure the seasonal and spatial impacts of the solar panels on evaporation.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
102	Soil, Plant, Water, Nutrient Relationships
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
125	Agroforestry
132	Weather and Climate
133	Pollution Prevention and Mitigation
402	Engineering Systems and Equipment
403	Waste Disposal, Recycling, and Reuse
404	Instrumentation and Control Systems
405	Drainage and Irrigation Systems and Facilities
511	New and Improved Non-Food Products and Processes
601	Economics of Agricultural Production and Farm Management
608	Community Resource Planning and Development
609	Economic Theory and Methods
903	Communication, Education, and Information Delivery

Outcome #7

1. Outcome Measures

Increased knowledge regarding the use of forest biomass as an energy source (Percentage increase in knowledge of attendees to workshops, field days, and demonstrations)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Western juniper is an invasive species that impacts western watersheds by replacing sagebrush-grassland ecotypes with closed canopy systems that displace native forage species and wildlife. Juniper removal is an expensive operation since there is no market for the wood.

What has been done
Supply curves were developed for juniper to be used as a biopower feedstock occurring on private lands within one half mile of existing roads. The model was further constrained by slope and transportation to a landing site for processing via torrefaction and subsequent transportation to an existing coal fired power plant. The ecological services and improvements to livestock production were also evaluated.

Results
A biomass subsidy of $10/bdt of harvested juniper would allow juniper to be used as an economically viable substitute for PBR coal. Juniper stands of sufficient density located with the allowable transportation constraint could conceivably supply sufficient supplies of torrefied juniper to fire a 300MW power plant for 12 years.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
125	Agroforestry

133	Pollution Prevention and Mitigation
403	Waste Disposal, Recycling, and Reuse
601	Economics of Agricultural Production and Farm Management
608	Community Resource Planning and Development
609	Economic Theory and Methods
903	Communication, Education, and Information Delivery

Outcome #8

1. **Outcome Measures**

Increased knowledge of wave energy, particularly by coastal stakeholders (Percent increase in knowledge of attendees to workshops, field days, and demonstrations)

Not Reporting on this Outcome Measure

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
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

There is currently a moratorium on planting canola and camelina in the Willamette Valley based on concerns that these plants represent a threat to the specialty seed producers through cross pollination. Environmental interests object to the production of Arundo because of its invasive characteristics.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Funding for bioenergy research from both government agencies and the private sector has declined with declining fossil fuel prices. As research surrounding sustainable energy has reached the demonstration and commercialization scale, funding and investment to cross "the valley of death" has been difficult to obtain. OSU has had success working with commercial enterprises to continue to advance research on biopower via substitution of torrefied materials for coal and use of forest residues for conversion to intermediate chemicals and jet fuel. Economic research on oilseeds continues to show promise for the use of this crop in rotation with or in conjunction with fallow wheat operations and as a

rotation crop for grass seed production. The implications of co-locating wind generation with crop production are now being developed with findings suggesting agricultural producers and wind generation entities will want to avoid each other to maximize the benefits of both operations.

Key Items of Evaluation

The current political climate suggests that research funding, tax incentives, production incentives, and limiting greenhouse gas emissions are no longer a priority and there is a reasonable expectation for this to continue until such time as fossil fuel prices rise in response to increasing demand. Much work remains to be done regarding the logistics and handling of biomass, storage, development of improved feedstocks, and improved conversion technologies to make bioenergy competitive with fossil energy. Current allocations to USDA for AFRI, BRDI, and CAP make such research very difficult to initiate. Similarly, proposed cuts to USDOE's EERE and BETO programs only magnify the need to restore funding to the bioenergy research portfolio.