V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

Water-Energy Nexus for 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			5%	
102	Soil, Plant, Water, Nutrient Relationships			15%	
111	Conservation and Efficient Use of Water			15%	
112	Watershed Protection and Management			5%	
132	Weather and Climate			5%	
133	Pollution Prevention and Mitigation			10%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			2%	
204	Plant Product Quality and Utility (Preharvest)			3%	
402	Engineering Systems and Equipment			15%	
403	Waste Disposal, Recycling, and Reuse			5%	
404	Instrumentation and Control Systems			5%	
405	Drainage and Irrigation Systems and Facilities			5%	
511	New and Improved Non-Food Products and Processes			5%	
902	Administration of Projects and Programs			5%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	3.0	0.0
Actual Paid Professional	0.0	0.0	4.4	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	291791	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	2236615	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	5626832	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

• Field experiments analyzing crop production responses, including methods that help reduce irigation water demand in various crops were conducted.
• Major analysis is underway to determine the effects of wind turbines on Irrigated agriculture. A graduate student started in the winter of 2014. 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.
• Following activities were conducted for the reporting period: 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. 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.

• Trials were conducted with Giant Reed and annual sorghum as a means to determine thier future use as a feedstock for biopower generation

2. Brief description of the target audience

The target audiences for this research are :

agricultural producers
renewable energy enterprises
policy makers
water mangagers
researchers

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2013	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	100	150	0	0

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

Patent Applications Submitted

Year: 2013

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	0	4	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- OTHER SCHOLARLY EXCELLENCE: participation on professional boards and panels, as well as science panels, awards, etc.

Year	Actual
2013	4

Output #2

Output Measure

- IMPROVED BIOPRODUCT PRODUCTION SYSTEMS . . . Indicators: 1-Improved technologies and production systems for biofuel and bioenergy (solar energy capture, fermentation, sensors); 2-Improved feedstocks (microbial, algal, agricultural byproducts, invasive species, cellulosic)

Year	Actual
2013	0

Output #3

Output Measure

- TECHNOLOGY, MODELS AND ANALYSES THAT INFORM DECISION-MAKERS, INDUSTRY, AND PEERS REGARDING AGRICULTURAL PRODUCTION: Indicators: 1- theoretical and computation tools (both parametric and non-parametric); 2-determinants of innovation in agricultural biotechnology

Year	Actual
2013	0

Output #4

Output Measure

- Objective 1:Develop and incorporate quantitative water, nitrogen and phosphorous use metrics into the attributional life cycle assessment.

Year	Actual
2013	50

Output #5

Output Measure

- Objective 2:Examine the biofuel and water nexus in the Pacific Northwest.

Year	Actual
2013	0

Output #6

Output Measure

- Objective 3:Evaluate the wind energy and water nexus in the Pacific Northwest.
  Not reporting on this Output for this Annual Report

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	K1...Improved knowledge about composition and conversion of feedstocks for biofuels, bioenergy, and co-products a) enhance use of existing varieties of algae, other micro-organisms, cellulosics, agricultural residues, and invasive species for bio-energy and coproducts b) new feedstock sources, extraction technologies, and co-products c) more acreages and tonnage of feedstocks used d) improved water use and quality
2	K2 ... Improved engineering applications to advance production systems for bioenergy a) optimize photobiological processes to yield higher energy efficiencies. b) demonstrate that waste biomass, such animal wastes and organic component of urban wastewater, used as feedstock can yield bioenergy and reduce waste and pollution sources.
3	K3 ... Models developed to look at biofuel and bioenergy productivity, technological processes, sustainability, and supply chain a) decision tools, economic and life cycle analyses, productivity analyses b) new technologies c) feedstock logistics d) resource inputs, outputs and quality e) land use change f) biodiversity
4	A1...Enhanced or improved bioeconomy a) number of new jobs b) increased revenue c) gallons of biofuels produced or consumed, gallons of fossil fuel displaced
5	A2...Implement sustainable biofuel supply chain a) acres or tons of feedstocks produced, numbers of farms involved in feedstock production b) number of technologies developed c) distributed conversion and processing
6	K4 - A framework for the attrbutional LCA based on the ISO standards will be extended to include water use metrics. These metrics will be defined based on source (confined and unconfined aquifers, surface runoff and precipitation), quality, quantity (consumptive and degradative use) and water stress index (volume of withdrawals in the watershed compared to the annual recharge) by adapting several published methods. Metrics for nitrogen and phosphorous utilization will also be developed along similar lines.
7	KA 5...Outcome 2-1: Biodiesel production from canola in the Pacific Northwest region will be used as a test case for the methodology developed in Objective 1. Previously developed process models incorporating feedstock handling, pretreatment, transesterification, and coproduct utilization, waste water handling will be further refined to incorporate process efficiency variations. Outcome 2-2: Cellulosic ethanol production from agricultural residues such as wheat straw and grass straw will be used to test the methodology developed in Objective 1. Outcome 2-3:Algal biofuels production will be modeled based on algae biomass production using municipal waste water as a nutrient source willbe performed. Processing of algae would be based on recently suggested scheme that consists of harvesting algae biomass using flocculation and processing the resulting slurry into biocrude using hydrothermal liquefaction process and the upgraded into green diesel and jet fuel.
8	KA - 6..Outcome 3-1: Examine idealized cases with LES utilizing simulation modeling compared with theoretical and field work.Outcome 3-2: Construct a model to represent the t the local topography of an individual farm to investigate the coupled effects of topography, spatial variability in water application and wind turbines

Outcome #1

1. Outcome Measures

K1...Improved knowledge about composition and conversion of feedstocks for biofuels, bioenergy, and co-products a) enhance use of existing varieties of algae, other micro-organisms, cellulosics, agricultural residues, and invasive species for bio-energy and coproducts b) new feedstock sources, extraction technologies, and co-products c) more acreages and tonnage of feedstocks used d) improved water use and quality

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)
Understanding better the role and physiology of nitrifying bacteria in the flow of nitrogen through the Nitrogen Cycle might result in significant reductions in energy required for nitrogen inputs into agriculture or for treatment of societal effluent. Understanding N transformation in unmanaged ecosystems, in wastewater treatment, and in soils amended with ammonia-based fertilizers, requires the thorough characterization of these organisms, singly, and while in the coupled two-step process.

What has been done
Constraints based models were built using a 2001 literature study as a framework. This study provided MFA and energetic models for hypothetical autotrophic nitrifiers with approximately 100 reactions and was done prior to the availability of published sequences for Nitrosomonas and Nitrobacter spp. The models will be updated to reflect current knowledge, with the final number of reactions being on the same order as the original models.

Results
To date, a metabolic reconstruction of N. europaea has been developed in this new effort. A reconstruction of N. hamburgensis has been developed using standard techniques. Both metabolic reconstruction models have been used to update the metabolic map provided by the 2001 .

4. Associated Knowledge Areas

KA Code	Knowledge Area

133	Pollution Prevention and Mitigation
402	Engineering Systems and Equipment
511	New and Improved Non-Food Products and Processes

Outcome #2

1. Outcome Measures

K2 ... Improved engineering applications to advance production systems for bioenergy a) optimize photobiological processes to yield higher energy efficiencies. b) demonstrate that waste biomass, such animal wastes and organic component of urban wastewater, used as feedstock can yield bioenergy and reduce waste and pollution sources.

Not Reporting on this Outcome Measure

Outcome #3

1. Outcome Measures

K3 ... Models developed to look at biofuel and bioenergy productivity, technological processes, sustainability, and supply chain a) decision tools, economic and life cycle analyses, productivity analyses b) new technologies c) feedstock logistics d) resource inputs, outputs and quality e) land use change f) biodiversity

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)
An economic analysis of the potential of western juniper was conducted to determine the use of this feedstock to be used to provide fuel for a biomass power plant. Rangeland and watershed restoration were used as potential economic drivers to support the use of juniper.

What has been done
The initial analysis was completed and a Master's thesis was prepared and accepted.

Results

Logistics of juniper harvesting and handling suggest that prices of $80.00/bdt would be required to support such an effort even when considering ecological services provided by juniper removal.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation
204	Plant Product Quality and Utility (Preharvest)
402	Engineering Systems and Equipment
511	New and Improved Non-Food Products and Processes

Outcome #4

1. Outcome Measures

A1...Enhanced or improved bioeconomy a) number of new jobs b) increased revenue c) gallons of biofuels produced or consumed, gallons of fossil fuel displaced

Not Reporting on this Outcome Measure

Outcome #5

1. Outcome Measures

A2...Implement sustainable biofuel supply chain a) acres or tons of feedstocks produced, numbers of farms involved in feedstock production b) number of technologies developed c) distributed conversion and processing

Not Reporting on this Outcome Measure

Outcome #6

1. Outcome Measures

K4 - A framework for the attrbutional LCA based on the ISO standards will be extended to include water use metrics. These metrics will be defined based on source (confined and unconfined aquifers, surface runoff and precipitation), quality, quantity (consumptive and degradative use) and water stress index (volume of withdrawals in the watershed compared to the annual recharge) by adapting several published methods. Metrics for nitrogen and phosphorous utilization will also be developed along similar lines.

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)
Current LCA models fail to adequately account for water demands associated with biofuel production. The GREET model is applied to a variety of landscape level analyses of the the potential impacts to watersheds from adoption of renewable energy approaches.Based on these previous results we will develop water use metrics that will incorporate the net energy value of the renewable energy, type of water (green/blue/gray water) and the water stress index at the watershed scale. The metrics for nitrogen and phosphorous use can be similar to EROWI concept described above. This metric will account for the net energy value of the fuel and the quantity of the nutrient used and therefore can be used to compare different technology alternatives.

What has been done
Three models will be developed to account for water usage in the production of bioenergy.We are also exploring the use of land as a functional unit to perform comparative analyses to identify differences in conclusions arising from the choice of land-use and energy as functional units.

Results
Preliminary work has been initiated. Access to private lands has created delays in preparation of the models. Models for assessing the impact of agricultural practices and weather on the emissions relevant for life cycle assessment during crop production have been initiated. An LCA for camelina production has be completed as have the LCA models for incorporating GBEP metrics.

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
132	Weather and Climate
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
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

Outcome #7

1. Outcome Measures

KA 5...Outcome 2-1: Biodiesel production from canola in the Pacific Northwest region will be used as a test case for the methodology developed in Objective 1. Previously developed process models incorporating feedstock handling, pretreatment, transesterification, and coproduct utilization, waste water handling will be further refined to incorporate process efficiency variations. Outcome 2-2: Cellulosic ethanol production from agricultural residues such as wheat straw and grass straw will be used to test the methodology developed in Objective 1. Outcome 2-3:Algal biofuels production will be modeled based on algae biomass production using municipal waste water as a nutrient source willbe performed. Processing of algae would be based on recently suggested scheme that consists of harvesting algae biomass using flocculation and processing the resulting slurry into biocrude using hydrothermal liquefaction process and the upgraded into green diesel and jet fuel.

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)
Biofuel LCA often fail to account for the change in water usage dynamics as a result of the production of feedstocks rather than water inputs as part of the conversion process. This is particularly important in areas with limited precipitation or where existing demand already exceeds available supplies.

What has been done
Three biofuel LCA models will be updated to include the relative impacts of water usage and nitrogen and phosphorus inputs in the production of biofuels from three different biofuel feedstock sources.

Results
This project has just begun with modeling efforts and data collection just beginning.

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
132	Weather and Climate
204	Plant Product Quality and Utility (Preharvest)
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

Outcome #8

1. Outcome Measures

KA - 6..Outcome 3-1: Examine idealized cases with LES utilizing simulation modeling compared with theoretical and field work.Outcome 3-2: Construct a model to represent the t the local topography of an individual farm to investigate the coupled effects of topography, spatial variability in water application and wind turbines

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)
We theorize that wind turbines create additional demands on soil moisture for irrigated crops and dry land cropping systems.While it is not yet possible to simulate the entire range of turbulent motions in the atmosphere, it is possible to simulate a significant portion of the energy-containing scales of motion while accounting for the effects of the smallest-scale
turbulent motions. The largest scales of turbulence contain most of the energy, are influenced by the (heterogeneous) boundary conditions, and are responsible for most of the turbulent transport of water vapor, while the smallest turbulent scales behave in a more idealized manner and are more amenable to parameterization.

What has been done

Lack of access to crop lands for data collection has caused us to revise our approach and use existing climatological data sets. Preliminary simulation models are being revised to accommodate this change. Landsat data is archived for 30 years of observation and evaporation can be extracted from the available images. This long-term observation allows us to assess the impact of wind farm installations by examining the evaporation before and after the wind farm was installed. The satellite approach also allows for a larger degree of replication. A PhD student has been hired to perform this analysis and her appointment begins on 04/01/14.

Results

Project is just beginning and models are being populated with available data. The complex interactions between wind turbine wakes, vertical mixing and horizontal advection are best decoupled in numerical simulations.Majo r analysis is underway to determine the effects o f wind turbines o n Irrigated agriculture. A graduate student started in the winter o f 20 14. 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.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
111	Conservation and Efficient Use of Water
132	Weather and Climate
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
402	Engineering Systems and Equipment

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Competing Public priorities
- Competing Programmatic Challenges
- Other (Data Access)

Brief Explanation

Farm scale acces to data has been limited by access to private lands. We believe access will eventually be granted over time as awareness concerning the importance of this information is accepted by landowners and renewable energy developerss

Additional funding is being sought to support field activities and students and applications have been submitted to two potential funding sources.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Simulation work for idealized cases is complete. We demonstrated that both field topography and wind turbines have a significant effect on evaporation. Taken together

they can increase the evaporation by over 16 % from nominal conditions . The impact of topography on evaporation is of the same order of magnitude as wind turbines . Field work has not been undertaken, significant barriers for land permissions were encountered. We have shifted strategy to analysis of satellite data to evaluate the impacts of large wind farms . Wind farm locations have been selected, and data analys is started in March o f 2014.

Key Items of Evaluation

The overall research objective is to **develop and test** a modified LCA framework based on land-use that incorporates water, nitrogen and phosphorous use metrics. This represents one of the first attempts to develop a framework for the attrbutional LCA based on the ISO standards that will be extended to include water use metrics. These metrics will be defined based on source (confined and unconfined aquifers, surface runoff and precipitation), quality, quantity (consumptive and degradative use) and water stress index (volume of withdrawals in the watershed compared to the annual recharge) by adapting several published methods. Metrics for nitrogen and phosphorous utilization will also be developed to provide a more comprehensive comparison between renewable and fossil fuels.