V(A). Planned Program (Summary)

Program # 6

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
201	Plant Genome, Genetics, and Genetic Mechanisms			8%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			23%	
204	Plant Product Quality and Utility (Preharvest)			42%	
206	Basic Plant Biology			27%	
	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	2.5	0.0
Actual Paid Professional	0.0	0.0	2.4	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	253371	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	96793	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Curly Top Gumweed Biofuel Potential

Three years of biomass field trials are completed. Lab analyses for bio-crude have produced a 12.5% yield. Economic projections show Gumweed will produce approximately 100-110 gallon/acre. The team is working to improve the extraction process using cheaper chemicals; acetone being the best candidate, thus far. The team has also been working on elucidating the catalytic reaction mechanisms and pathways to convert Gumweed's bio-crude into hydrocarbons. Trails have been completed in electro-chemically process transforming grindelic acid (the important component of the Gumweed's bio-crude) into a C19 hydrocarbon biofuel. As a secondary line of research, the team is also looking at grindelic acid as a substitute for abietic acid (rosin), a commodity chemical used in glues. Currently the team is look into methods that de-colorize the product to approximate commercial lines.

Improving Camelina as a Biofuel Alternative

Varietal trials were conducted over the past year to determine best seed yields and aerial biomass, with seed oil content to be determined in 2014. Progress was made on the screening of over 7,000 mutant Camelina populations. A third generation mutants lines has been found that expresses a stable mucilage-free defect, important in reducing the gum during oil extraction. Advancements in creating glyphosate (RoundUp®) resistant varieties are moving forward. Eleven lines have been generated and are undergoing validation in the next generation of plants.

Sequencing of Camelina's RNAs were completed, giving insights to major genetic determinants responsible for stress-adaptive responses. A total of 4,046,718 quality and adapter-trimmed were generated from root, leaf, stem, flower, and seedpod tissues subjected to abiotic stresses over a 24 h period including water deficit, salinity, heat, cold, and normal (control) growing conditions. These reads were assembled into transcript contigs. The data is now being complemented by paired-end Illumina sequencing.

Accumulation of Hydrocarbons in Plants - making biofuels

Camelina is general not thought of as a good field crop because of seed size. Our research team's goal is to either make bigger seeds or more of them per plant. The team has recently completed engineering Arabidopsis plants with two genes used to convert long-chain fatty acids into non-oxygenated long-chain hydrocarbons (biofuel). Two new enzyme promoters were designed to express the novel genes in leaves or seeds. Both novel genes have now been optimized for insertion into Camelina and have been cloned into different constructs that target specific parts of the plant (leaf cells, chloroplast - photosynthetic machinery, plastids - storage organelles, and seeds).

Prickly Pear Cactus Feedstock

RNA sequencing has been completed for 84 Prickly Pear pad (cladode) samples providing a detailed comparison of the mRNA expression levels between pads under well-watered and drought-stressed conditions. Genetic constructs for use in Prickly Pear have been designed based upon recent breakthroughs in metabolic engineering, i.e., the 'push', 'pull', and 'protect' strategies. Evaluation of structural proteins of Prickly Pear's oil bodies has just begun.

2. Brief description of the target audience

Those most affected by this research include the general public, energy and chemical industry, and potential producers.

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	339	0	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	9	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Peer reviewed journal articles, publications in commodity group publications, presentations at scientific meetings, presentations at stakeholder, Native American and agency meetings.
  Not reporting on this Output for this Annual Report

Output #2

Output Measure

- Demonstrations and Field Days Conducted

Year	Actual
2013	3

Output #3

Output Measure

- Number of Graduate Students or Post-Doctorates Trained

Year	Actual
2013	7

Output #4

Output Measure

- Number of Undergraduate Students Involved in Research

Year	Actual
2013	14

Output #5

Output Measure

- Research Projects Conducted
  Not reporting on this Output for this Annual Report

Output #6

Output Measure

- Leveraged Research Projects

Year	Actual
2013	4574499

Output #7

Output Measure

- Web Sites Created or Updated

Year	Actual
2013	2

Output #8

Output Measure

- Workshops, Demonstrations, and Presentations

Year	Actual
2013	18

Output #9

Output Measure

- Abstracts, Books, Book Chapter(s), Proceedings, Research Reports, and Technical Publications

Year	Actual
2013	2

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Peer reviewed journal articles, publications in commodity group publications, presentations at scientific meetings, presentations at stakeholder, Native American and agency meetings.
2	Developing Prickly Pear Cactus as a Biofuel Feedstock

Outcome #1

1. Outcome Measures

Peer reviewed journal articles, publications in commodity group publications, presentations at scientific meetings, presentations at stakeholder, Native American and agency meetings.

Not Reporting on this Outcome Measure

Outcome #2

1. Outcome Measures

Developing Prickly Pear Cactus as a Biofuel Feedstock

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 long-term goal of the proposed research is to develop prickly pear cactus (Opuntia ficus-indica and related species) as a new biofuel and feed crop in the arid western region. Our vision is to create a novel biofuel feedstock production platform with increased energy density within vegetative tissues that is capable of producing biodiesel, renewable diesel, or jet fuel with only 20% the water inputs required for traditional biofuel feedstocks. While prickly pear cactus is currently used for food and feed in limited areas, this research will expand the use of this crop species into a sustainable biofuel production system on marginal, semi-arid lands that are currently underutilized.

What has been done
Transcriptomic sequencing has been completed using Illumina RNA-seq technology for 84 prickly pear cladode samples collected every 4 hours over a 24 h day-night time course. Two different tissue types (e.g. mesophyll and epidermis) were also sampled in parallel. Constructs for use in prickly pear have been designed based upon metabolic engineering concepts of 'push', 'pull', and 'protect'. The "Bioenergy Crops for Semi-arid Environments" Educational Display was completed and introduced to farmers, stakeholders and the general public.

Results
Information garnered from this project have begun to influence how other scientists are applying this breakthrough metabolic engineering concept. A new method for the removal of high volumes of pectin was developed that will help future researchers quickly extract RNA from similar plants. The observations witnessed validates the strategy to use drought stress-inducible promoters to drive the over-accumulation of lipids within vegetative tissues and should further future research into delivering oilseed-like levels of triglycerides into model plants.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
206	Basic Plant Biology

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Appropriations changes

Brief Explanation

{No Data Entered}

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Nevada's research projects have an evaluative element that is required by state and federal-level funding sources that provides documentation related to project assumptions, goals and outcomes. This information is used to determine the overall success of research initiatives; their contribution to providing practical, real-world solutions and resources to address challenges and problems; and whether continuation funding and/or new dollars are appropriate and necessary as funds are available.

- Developing prickly pear cactus into a biofuel feedstock
- Leveraged over $4.5M in extramural funding.
- Trained 21 students and post-docs
- Conducted 18 workshop/demonstrations on biofuel production

Key Items of Evaluation

A breakthrough in removal of pectin methods will expedite metabolic engineering for scientists working in biofuel production from plant materials high in pectin.