

**V(A). Planned Program (Summary)**

**Program # 1**

**1. Name of the Planned Program**

Climate Change and Environment

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			10%	
102	Soil, Plant, Water, Nutrient Relationships			13%	
111	Conservation and Efficient Use of Water			10%	
112	Watershed Protection and Management			5%	
121	Management of Range Resources			5%	
122	Management and Control of Forest and Range Fires			5%	
132	Weather and Climate			12%	
133	Pollution Prevention and Mitigation			12%	
136	Conservation of Biological Diversity			12%	
201	Plant Genome, Genetics, and Genetic Mechanisms			5%	
216	Integrated Pest Management Systems			5%	
903	Communication, Education, and Information Delivery			6%	
	<b>Total</b>			100%	

**V(C). Planned Program (Inputs)**

**1. Actual amount of FTE/SYs expended this Program**

Year: 2014	Extension		Research	
	1862	1890	1862	1890
<b>Plan</b>	0.0	0.0	76.6	0.0
<b>Actual Paid</b>	0.0	0.0	61.7	0.0
<b>Actual Volunteer</b>	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	446567	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	2975805	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2130885	0

**V(D). Planned Program (Activity)**

**1. Brief description of the Activity**

In the northern Rocky Mountain west, climate change and environmental studies are becoming increasingly necessary as major environmental changes continue to accelerate. COA/MAES faculty scientists at MSU are actively recruiting competitive grant dollars and personnel to bolster current and forecasted research faculty lines, undergraduate and graduate students, programs and labs, as they relate indirectly and directly to climate change studies. Direct impacts from climate change not only to traditional production agriculture, but in many of the west's forests, watersheds, soils and ecosystems are currently being observed and felt at both economic and environmental levels. Because of such, many facets of this program area have outgrown annual accomplishments as previously articulated this annual report's corresponding 2014-2018 Plan of Work. In 2014, major research findings, publications and outreach initiatives in climate change have been successful thanks to continued Hatch funding. This program area saw an increase in nine new Hatch projects, many of them interdisciplinary in nature - as they speak to the myriad fields that rapid climate change has affected.

Not surprisingly, researchers learn more about climate change they are concerned about the potential impact on forests and rangelands and the ecosystems. Experts warn a warmer climate will likely result in more disturbances such as wildfires, floods, droughts, insect infestations, and an increase in invasive plants. While agriculture is vulnerable to climate change as diminished water resources constrain crop growth, which also must be considered in context of rising timberlines, land use, and invasive species.

MSU is uniquely poised and geographically blessed to be a leader in regional climate change studies, as the state's only 1862 land-grant intuition. The growth this year (in research production and program growth in climatic studies) in is representative of COA/MAES as a regional leader in climate studies housed within a STEM Land-grant university. The university's proximity to Yellowstone National Park, within a valley floor surrounded by national forests, wilderness, and agricultural rangeland (the county and state's leading economic driver) allows MSU to continue as a foundational public university that is growing a strong and dedicated climate change research portfolio. Several of the main veins of research priorities surrounding climatic influence parallel research fields such as: wildfires, wildlife, ground water sustainability and resources, watershed protection and management, cropping system sustainability, carbon sequestration, biofuel and biomaterial development, health and vibrancy of pollinator populations, diversity of trees and forestlands, and soil moisture retention and adaption studies. Through basic and applied research in these fields, COA/MAES is also able to support the drafting of national agricultural and environmental policy formulas, as a result of a growing base of collaborative work with peer institutions across the nation.

As the climate changes, the need for drought resistant cultivars of Montana crops increases. Therefore, researchers continue discovering and evaluating new crops and cultivars of spring wheat, winter wheat and barley suitable for a warmer and drier climate. They are also studying how climate change impacts various pests throughout the State.

Educational programs are being established as an introduction to the aspects of global climate change and its implications for agriculture. Agriculture has the potential to contribute to mitigation of climate change by sequestering carbon in soils. One MSU project is gathering data to produce scientific publications and information for the general public that will improve the ability of public decision-makers to formulate policies regarding climate change and greenhouse gas mitigation. Additional projects are investigating the potential for soil carbon sequestration in rangelands and croplands. Studies also made progress in learning more about seasonal patterns and cumulative N<sub>2</sub>O emissions from agricultural soils in the Northern Great Plains under different cropping systems, water regimens crop residue levels, and nitrogen fertility rates.

As the demand for water increases and resources decline, researchers are designing forecast and water management models for watershed and runoff controls. COA scientists focused on three activities (1) the development and assessment of new hydrologic models for mountain headwater catchments; (2) developing methods for model calibration and Bayesian inference for hydrologic models; and (3) implementing methods for predictions and quantification of uncertainties in ungauged catchments.

In the COA's Department of Land Resources is the Montana Institute on Ecosystems, a multi-institutional community dedicated to understanding complex ecosystems and the interconnectedness of people, nature, climate pressure, healthy ecosystems and economic growth. The center draws on the extraordinary landscapes of Montana and beyond to advance integrated environmental sciences and related fields. The center allots several undergraduate and graduate research opportunities on a variety of subjects as they related to climate change. These students are regularly named as bright candidates for research and advanced schooling fellowships.

As the nation develops a responsive adaptation to climate change, COA/MAES scientists continue to make great strides in this critical research agenda to continue excelling in the discovery and communication of how natural and managed environments and their elements function in an era of global climate change. Some of these aforementioned advancements in 2014 climate change studies are outlined below:

- Development of bio-based products ; polymeric materials for eco-friendly crop production
- Wheat rotation management impacts on evapotranspiration, carbon dioxide exchange and soil moisture status
- Biogeochemical consequences of canopy tree diversity in tropical watersheds
- Improved oil compositions in Camelina to meet the need for renewable and clean sources of industrial products
- Address the growing need for renewable sources of environmentally friendly biofuels and biomaterials to replace products currently manufactured from petroleum.
- Find optimum density of big sagebrush within a watershed that facilitates groundwater recovery as well as sufficient shrub density/cover to support ecological function and wildlife habitat.
- Develop quantitative approaches for describing microbial controls on the biogeochemical cycling of crustal constituents.
- Study soil processes and arbuscular mycorrhizal function across a gradient of management activities

related to restoration and agriculture.

- Diversity and distribution of mycorrhizal fungi that support woody plants and trees in Montana and biologically related regions
- Floodplain sediment/channel water exchange studies
- Promote a deeper understanding of our relationship with the viticultural landscape, for the benefit of sustainable practices
- Alfalfa leafcutting bee thermal biology
- Prescribed burning to suppress conifer invasion into foothill rangeland
- Current and forecast future impacts on disturbance of TCEF and Yellowstone National Park ecosystems
- Pollinator colony health and sustainability
- Using airborne and satellite imagery to support monitoring and validation related to efforts to sequester carbon in Montana
- Characterize abiotic and biotic reaction mechanisms, transformation rates and fate of chemicals in agricultural and natural ecosystems
- Addressing the uncertainty in hydrologic systems (sustainable management of water in climatic uncertainty)
- Drinking water standards (metalloids)
- Basic and applied studies of natural geothermal microbial resources
- Measure and quantify gaseous loss of NH<sub>3</sub> from fertilizer N applications and legume green manures, and to evaluate products and management practices to mitigate emissions.
- Research surrounding endemic root and crown disease problems facing small grain growers in Montana

## **2. Brief description of the target audience**

- Crop and livestock producers in Montana
- State agricultural advisory committees
- State of Montana, Montana Department of Agriculture, BLM, USFS, and other government entities
- Participants in extension and commodity group meetings, conferences, and field days
- Regional and local water-shed and groundwater community groups
- Climate studies scientists and students
- Statewide natural resource

## **3. How was eXtension used?**

COA and MAES researchers worked closely with county extension agents and outreach coordinators to disseminate timely and accurate information regarding the evaluation and procurement of research advancements made in climate studies and the environment. Many of these research projects were spoken of during MAES field days, throughout MSU/COA's seven research centers across the state.

## **V(E). Planned Program (Outputs)**

### **1. Standard output measures**

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
<b>Actual</b>	50000	25000	2000	1000

**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
<b>Actual</b>	0	95	95

**V(F). State Defined Outputs**

**Output Target**

**Output #1**

**Output Measure**

- Number of research citations

<b>Year</b>	<b>Actual</b>
2014	95

**V(G). State Defined Outcomes**

**V. State Defined Outcomes Table of Content**

O. No.	OUTCOME NAME
1	Number of new stress tolerant crop recommendations (or changes) for Montana
2	Number of new technologies explored

## **Outcome #1**

### **1. Outcome Measures**

Number of new stress tolerant crop recommendations (or changes) for Montana

### **2. Associated Institution Types**

- 1862 Research

### **3a. Outcome Type:**

Change in Action Outcome Measure

### **3b. Quantitative Outcome**

<b>Year</b>	<b>Actual</b>
2014	2

### **3c. Qualitative Outcome or Impact Statement**

#### **Issue (Who cares and Why)**

Small grains are an extremely important component of Montana agriculture; eastern Montana produced nearly 48 million bushels of spring wheat in 2010, about 45% of the spring wheat produced in Montana. These figures are still accurate in 2014. More foreign markets are showing interest in purchasing durum from this area, and malt barley acres have increased in Montana and western North Dakota, as private agribusinesses have contracted up to 20 million bushels. Both wheat producers and wheat buyers are demanding higher-yield potential and resistance to climate stresses and pests.

#### **What has been done**

Two new wheat lines, Egan (winter), and Sliver (durum) were recommended to state agricultural producers and wheat growers. Both varieties are pest and stress tolerant, as factors related to climate change. Egan was released commercially and Sliver underwent standard field trials and characteristic tests.

#### **Results**

Egan was released as commercial seed, and it is the first variety for Montana with resistance to the orange wheat blossom midge. A paper published regarding genetic difference between modern and historical varieties will provide guidance to breeds for selection priorities. A novel gene for wheat stem sawfly resistance was identified. The experimental line for MT 1320 yielded most in a dryland trial. The data from the trials and subsequent yields have been disseminated to agricultural producers, industry and commodity group personnel, economic development boards and scientific peers. A continuation of of experimental durum lines that have highly-sought after characteristics will progress.

#### 4. Associated Knowledge Areas

<b>KA Code</b>	<b>Knowledge Area</b>
102	Soil, Plant, Water, Nutrient Relationships
111	Conservation and Efficient Use of Water
121	Management of Range Resources
132	Weather and Climate
136	Conservation of Biological Diversity
201	Plant Genome, Genetics, and Genetic Mechanisms
216	Integrated Pest Management Systems
903	Communication, Education, and Information Delivery

#### Outcome #2

##### 1. Outcome Measures

Number of new technologies explored

##### 2. Associated Institution Types

- 1862 Research

##### 3a. Outcome Type:

Change in Knowledge Outcome Measure

##### 3b. Quantitative Outcome

<b>Year</b>	<b>Actual</b>
2014	1

##### 3c. Qualitative Outcome or Impact Statement

###### **Issue (Who cares and Why)**

Remote sensing technologies (analysis of imagery from airplanes and satellites) are becoming increasingly useful in issues related to land-resources and climate studies in the state. In many cases, only satellite imagery can be used to analyze spatial and temporal patterns of historical adoption of such practices and to help understand and guide future outreach and extension efforts.

###### **What has been done**

As focus on the impacts of atmospheric CO<sub>2</sub> increases, factors affecting sequestration also become more important. There were several significant accomplishments with respect to monitoring sites for leakage. Scientists determined that alfalfa subjected to CO<sub>2</sub> stress, exhibited a different spectral responses than alfalfa subjected to water stress. This was a critical step in

being able to uniquely identify potential responses to a leak at a geologic sequestration site. Tremendous progress was made in examining patterns of adoption of agricultural practices related to carbon sequestration using multitemporal satellite imagery.

### **Results**

The results of such are expected to be applied to additional field studies for geologic carbon sequestration. Results to date have focused on greenhouse studies and field-based, controlled experiments.

## **4. Associated Knowledge Areas**

<b>KA Code</b>	<b>Knowledge Area</b>
101	Appraisal of Soil Resources
102	Soil, Plant, Water, Nutrient Relationships
132	Weather and Climate
133	Pollution Prevention and Mitigation
201	Plant Genome, Genetics, and Genetic Mechanisms
903	Communication, Education, and Information Delivery

## **V(H). Planned Program (External Factors)**

### **External factors which affected outcomes**

- Natural Disasters (drought, weather extremes, etc.)
- Appropriations changes
- Public Policy changes
- Government Regulations

### **Brief Explanation**

- Inadequate funding and technical support from partnering institutions and cooperators
- Inadequate moisture (rainfall, irrigation, snowpack) for consistent crop production
- Lack of full-time staff and part time assistant
- Major interruptions in program development

The 2014 crop year faced warm and limited precipitation throughout the year, but when precipitation was received hail often accompanied the storm. Montana recorded a record amount of acreage damaged by hail.

## **V(I). Planned Program (Evaluation Studies)**

### **Evaluation Results**

Evaluation studies were successful through the issuance and collection of surveys, published peer reviewed materials and securing peer reviewed grants. Notable evaluation results: Researchers disseminated the results to the agricultural community at grower meetings, Certified Crop Adviser meetings, industry conferences, and MAES field days. They also shared the information with agricultural professionals at the American Society of Agronomy National

meetings.

The investigator developed a web site to keep growers, agricultural consultants, and other interested parties up-to-date on the progress of various studies.

Results of a long-term study on linking upland plant community structure and riparian processes resulted in a riparian rehabilitation guide for private and public land managers. Experts in the riparian processes distributed 700 of the guides in four Montana counties and hosted several workshops to explain how to rehabilitate degraded riparian areas. A new website was developed and is used to forecast spring and winter wheat basis in various Montana locations and can be found at <http://wheatbasis.montana.edu>.

### **Key Items of Evaluation**

MSU COA researchers advanced crop options for a warmer and drier climate:

Developed a new winter wheat line, "Egan" - commercially sold and patent-pending approval (see Plant Sciences and Products program area)

- Developed two new spring wheats varieties called "WB9879CLP" and "Silver" durum
- A winter wheat, "SY Clearstone"
- Increased planting of "Vida," a drought resistant variety of spring wheat which was the top choice for growers in 2011 and 2012
- Researchers developed and shared new knowledge about carbon sequestration
- Created a riparian rehabilitation guide
- Furthered research helping forests and rangelands with emphasis on whitebark pine and sage