V(A). Planned Program (Summary)

Program # 3

1. Name of the Planned Program

Climate Change

☑ 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
102	Soil, Plant, Water, Nutrient Relationships	20%		40%	
104	Protect Soil from Harmful Effects of Natural Elements	20%		25%	
123	Management and Sustainability of Forest Resources	20%		20%	
132	Weather and Climate	20%		5%	
605	Natural Resource and Environmental Economics	20%		10%	
	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	0.0	0.0	16.3	0.0
Actual Paid	0.0	0.0	52.3	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	762169	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	3000226	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	5723578	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

MAES research on climate change is broad and interdisciplinary, utilizing both basic and applied research techniques. It ranges from climatology to forestry to water resources and agricultural products. Research has focused on three areas: building understanding on what is happening to our climate; mitigation--discovering ways to prevent warming from getting significantly worse in the future; and adoption--building resilience into forest and agriculture systems so they are less susceptible to disruption by changing climates.

Research highlights for 2014 include:

- Researchers have developed the first regional evaluation of the total greenhouse gas budget associated with agricultural activity in the Upper Midwest. The results showed a near-neutral impact on climate change and climate change studies in the Upper Midwest should include CH4 and N2O emissions, not only CO2.
- U of M researchers are exploring phenology as a way to measure the effects of climate change on Minnesota's plants and animals. Armed with 120 years of historical data housed at the U's Herbarium, University scientists recorded flowering, fruiting, and leafing dates from 11,489 plant specimens, representing nine different plant families. They were able to discover enough data to develop statistical analysis for 68 percent of their target species.
- Research work on proper levels of nitrogen (N) fertilizer to use while maintaining yield has led growers in irrigated sandy soils to increase their attention to the amount of N fertilizer applied to corn, as well as, the timing of these applications.
- Forest researchers studying afforestation and reforestation to mitigate climate change completed a simulation that showed there is not enough land available to house both forests and crops for food and feed. Looking at North America, the simulation found only British Columbia has a suitable environment for forest plantations that would sequester ample amounts of carbon.
- Scientists developed a new global model for simulating atmospheric nitrous oxide. An analysis is currently underway.
- A model developed to explore the effects of climate change on Midwest agriculture predicts that maize yield will decline in Iowa as temperatures rise. For every one degree Celsius increase, the model predicts a 4.6 percent decline in yield.
- Scientists exploring pennycress as an alternative crop, and weed management strategy, installed new water sensors in fall 2014 that will record soil water content for each plant row throughout the 2015 growing season.

- In an ongoing project working to establish new nutrient management guidelines for sweet corn and other specialty crops, experimental plots were established at the Southern Research and Outreach Center in Waseca with six various levels and types of N fertilizer.
- Researchers looking for alternative tree species to plant in Black Ash forests affected by emerald ash borer, found hardwood species, including swamp white oak, hackberry, and American elm, are able to survive and could be potential replacement species.
- A study on the effects of biomass harvesting on forest productivity indicates removal of harvest residues in aspen-dominated forests has little impact on soil carbon and nitrogen in the medium term (20 years). But forests developing following biomass harvests may develop at a slower rate than areas experiencing less intensive management regimes.
- A study on how minerals affect how soil stores carbon found that exotic earthworms significantly altered the carbon and nutrient cycle in Minnesota forests.
- Researchers completed a study on how Mesotrione, a new herbicide developed to control weeds in corn, interacts with E. coli. The results showed E. coli survived well in the presence of high concentrations of Mesotrione and the herbicide degraded after three hours of exposure. This study suggests there may be a general adaptation built in that allows bacterial strains to resist damage from herbicides.

Extension. Minnesota is the fastest warming state in the nation during winter months. The average global temperature has risen about one and a half degrees in the past century. In Minnesota, the average temperature has risen about two degrees in the past century. Parts of northern Minnesota have warmed nearly three degrees. Cold weather species like moose and lake trout are disappearing. Maple trees are migrating north. Bugs that once were killed off by harsh winter conditions are surviving to threaten tens of thousands of acres of forest. Lake Superior is one of the fastest warming lakes on the planet. Compared to most other states, Minnesota has experienced faster temperature increases and greater increases in significant rainstorms. All of this has refocused Extension programming that respond to new pressures on cropping systems, greater soil erosion, new forest insect pests, and other changes. Efforts in response to the effects of climate change are reported in the Global Food Security, Water Resources and Forestry and Forest Products Program sections of this report. Efforts specific to Extension educational programming about climate change in Minnesota are reported here. They focus on a 2014 conference, "Building Minnesota's Capacity for Climate Adaptation."

2. Brief description of the target audience

Extension target audiences include decision makers and leaders responsible for preparing communities for change. This includes local government and policy makers, state and local elected officials, environmental groups, water and soil conservation district managers, local officials from watershed districts, the Minnesota Pollution Control, Minnesota Department of Transportation, state emergency managers, and educators.

MAES. Research target audiences also include audiences whose production systems will be influenced by climate change, as well as those who consult or influence the decision-makers of these growers and producers. Other specific audiences include producers and environmental groups, forestry groups, human health services, FEMA, and Extension educators working in food and nutrition, family and community life, and climatology.

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	410	0	0	0

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	2	44	46

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Research will increase acreage devoted to studying climate effects on crops.

Year	Actual
2014	12

Output #2

Output Measure

- Extension will educate targeted groups, community leaders and citizens to increase knowledge and understanding of climate change issues. (Target expressed as the number of events.)

Year	Actual
2014	13

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Research will develop new knowledge and technologies related to climate change. (Measure: number of new crop varieties and genotypes with climate adaptive traits; number of new assessment and management tools developed, including models and measurements; number of new climate relevant databases, monitoring systems and inventories managed or under development)
2	Extension will educate targeted audiences, community leaders and citizens on climate change issues.
3	Research will provide information and guidance to forest managers working to save northern forests from emerald ash borer and climate change.

Outcome #1

1. Outcome Measures

Research will develop new knowledge and technologies related to climate change. (Measure: number of new crop varieties and genotypes with climate adaptive traits; number of new assessment and management tools developed, including models and measurements; number of new climate relevant databases, monitoring systems and inventories managed or under development)

2. Associated Institution Types

- 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)
Feeding a growing world will require expanded agricultural production, which may require the conversion of grasslands and forests into cropland. Such conversions can reduce carbon storage, habitat provision and other ecosystem services which presents difficult societal trade-offs.

What has been done
Researchers collected data for 175 crops and pixel mapping of every 9x9 minute surface of the earth to answer how global food demands can be met without compromising carbon stores as ecosystem services. Their model allowed them to identify heavily farmed areas like the U.S. Corn Belt, parts of Western Europe, and eastern China, among others, and seek areas for potential extensification of agricultural land. Results showed the value of focusing on selective extensification in areas surrounding existing highly productive agricultural areas to limit carbon trade-offs while still meeting global agricultural demands in the future.

Results
By focusing on selective areas to expand agriculture in the future, researchers estimate they can save over $1 trillion (2012 US dollars) worth of carbon storage relative to proportional expansion. Study results have been shared with academics, government officials, and national and international agencies.

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources
132	Weather and Climate
605	Natural Resource and Environmental Economics

Outcome #2

1. Outcome Measures

Extension will educate targeted audiences, community leaders and citizens on climate change issues.

2. Associated Institution Types

- 1862 Extension

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)
The evidence for climate change in Minnesota is convincing, and respondents to a survey of those who participated in the 2013 Climate Change conference reported they didn't need more information on the proof of climate change at the 2014 conference. "You don't need to preach to the choir," one participant said. Rather, they wanted information from Extension on how agricultural producers, forest managers, concerned citizens, and local communities could respond to the effects of climate change.

What has been done
Due to overwhelming interest, the 2014 Climate Change conference was moved to a larger venue to accommodate demand, and registration was capped at 250 to allow for maximum participation. Extension coordinated a statewide Climate Adaptation Partnership to host the conference, which presented case studies, examples, and strategies for responding to the effects of climate change in Minnesota. Break out sessions focused on recreation and tourism, watershed management, plant ecology, and agriculture.

Results
The conference received broad coverage in the media. Minnesota Public Radio produced a series of stories, and an Associated Press report was picked up by national media, including USA Today. A more important result was the action that participants reported they would take following the conference. For example, the Minnesota Department of Transportation has changed the way it orders pipe, so that they would be prepared for extreme flooding events. Participants said they would be taking tools, methods, and strategies presented to develop adaptive practices in their local communities and organizations.

4. Associated Knowledge Areas

KA Code	Knowledge Area
132	Weather and Climate

Outcome #3

1. Outcome Measures

Research will provide information and guidance to forest managers working to save northern forests from emerald ash borer and climate change.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Emerald ash borer (EAB) has killed millions of ash trees across the Midwest and Canada. In Minnesota, infestations have been found in the southeastern corner of the state and the Twin Cities metro area. Researchers and environmentalists are concerned how EAB will affect our Northern Black Ash forests which house nearly one billion ash trees on over one million acres.

What has been done
Researchers simulated an emerald ash borer invasion on a four acre plot in Chippewa National Forest. They "girdled" the trees, on the plot effectively killing them. In just two years, a dramatic change had taken place--a once fertile forest wetland was now a grass dominated wetland with flood conditions persisting for six to eight weeks longer than nearby forest areas. This new picture

presents little opportunity for new trees to thrive--especially considering the joint looming threats of EAB and climate change. In another area of nearby forest sections of black ash were selectively cut down with the intent of leaving enough trees to control the water table, and allow for new species to take hold before EAB arrives.

Results

Findings suggest that hardwood species, including swamp white oak, hackberry, and American elm can survive on black ash sites, and could serve as replacement species. Several of these, while being resistant to EAB, are also traditionally found in southern Minnesota forests, and would be more adapted to a warmer climate. The thinning process is now starting in other areas of the Chippewa National Forest with plans to plant replacement species on over 4,000 acres. The plan is to shift the forest away from black ash before EAB takes hold.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
104	Protect Soil from Harmful Effects of Natural Elements
123	Management and Sustainability of Forest Resources
132	Weather and Climate
605	Natural Resource and Environmental Economics

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Competing Programmatic Challenges
- Other (Reporting strategies)

Brief Explanation

Climate change knowledge is incorporated into many Extension programs, each with its own evaluation and management structures. This federal program is used to describe UMN's efforts to describe climate change as an educational topic.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

At our climate change event, evaluation focused only on the satisfaction of attendees, ideas for using the information, and ideas for future events.

Key Items of Evaluation

The overwhelming interest in gathering information related to climate change puts UMN Extension and research in a position of leadership throughout the state, attracting media and leaders from many sectors to educational discussions.