V(A). Planned Program (Summary)

Program # 7

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	15%	15%	15%	15%
111	Conservation and Efficient Use of Water	10%	10%	10%	10%
132	Weather and Climate	10%	10%	10%	10%
136	Conservation of Biological Diversity	5%	5%	5%	5%
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants	10%	10%	10%	10%
205	Plant Management Systems	10%	10%	10%	10%
305	Animal Physiological Processes	10%	10%	10%	10%
307	Animal Management Systems	10%	10%	10%	10%
311	Animal Diseases	5%	5%	5%	5%
601	Economics of Agricultural Production and Farm Management	5%	5%	5%	5%
605	Natural Resource and Environmental Economics	5%	5%	5%	5%
903	Communication, Education, and Information Delivery	5%	5%	5%	5%
	Total	100%	100%	100%	100%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	9.0	1.5	20.0	1.5
Actual Paid Professional	7.0	0.4	20.7	1.0
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**
404553	142194	658570	170496
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
278867	142194	348557	170496
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
956101	11198	3889098	133187

V(D). Planned Program (Activity)

1. Brief description of the Activity

Research and extensions programs will focus on: (1) Animal agriculture: understanding impacts of climate change on animal physiological processes, health, and disease, particularly for poultry and dairy; developing management practices to rapidly diagnose, prevent, and mitigate (e.g., new vaccines) effects of avian diseases on poultry health and productivity, including current disease problems and new ones that may appear and proliferate under new climatic conditions; developing new systems and technologies to reduce effects of environmental stress on animal health and productivity; latest research projects are focusing on animal care, management and environmental design to ensure animal well-being and raise awareness of environmental protection, law and legislation. These studies are on four fronts, including monitoring technologies for animal physiological and behavioral response, assessment of animal-environment interactions, quantitation of air quality and emissions from animal feeding operations, and assessment and development of best management practices aiming at mitigating air emissions based on their character, amount, and dispersion. (2) Agronomic crops: basic research on how environmental stresses associated with climate change (e.g., heat, moisture stress) affect crop physiology and productivity; plant genetics and breeding studies to develop cultivars of major crops better adapted to a changing climate, in terms of water use efficiency and resistance to insects and disease; applied research and extension programs on irrigation management and water use efficiency for periods of prolonged drought and restricted water use and for groundwaters that may become more saline from salt water intrusion; integrated pest management to diagnose and control insects, weeds, and diseases (current and newly emerging) during longer growing seasons and under warmer and wetter growing conditions; nutrient cycling and management, particularly for manures and other byproducts where decomposition and nutrient release rates and timings are affected by warmer, wetter climates; basic and applied research on factors controlling C sequestration and new agronomic management practices that help mitigate greenhouse gas emissions by sequestering C in soils; and new studies now underway on how changing temperature and rainfall patterns will affect phosphorous management and water quality impacts, using isotope geochemistry to identify how and why the phosphorous has been released from cropland to surface and ground waters. (3) Natural Ecosystems: characterizing effects of climate change on biodiversity of plants and wildlife exposed to greater pressure from droughts, insects, disease, and invasive species; studying how climate change affects natural ecosystems and insects critical to crop production (e.g., pollination, honeybees); investigate value of marshes, wetlands, and forests to sequester C; increase C storage by encouraging tree planting and sustainable forestry management; and new studies using weather radar to quantify bird distributions and to track migratory birds. Understanding stopover ecology of migratory birds, including how they select the habitats where they stop and how that impacts their behavior and the success of their migrations, as climate change occurs, is an important area of ecological research today. Two new projects will collectively map important stopover areas for birds during their migrations along the entire US Atlantic coast using the national network of weather radars; (4) Resource

economics: develop creative new economic policies to profitably link agriculture and forestry with those sectors generating significant quantities of greenhouse gases (e.g., energy, transportation) in cooperative efforts to mitigate greenhouse gas emissions; improve understanding of the relationship of climate change to agricultural and environmental policy development, including farmland preservation, conservation reserve programs; study impacts of climate change on groundwater aquifers, integrate climate change into the Chesapeake Bay water quality model; contribute to policies and educational programs on recycling, develop environmentally-friendly bio-based fuels from local feed stocks, and assist in analysis of Delaware's greenhouse gas inventories from energy use (mobile sources, utilities, residential, industrial, transportation, commercial, natural gas distribution, waste management, agriculture, land use, etc.).

2. Brief description of the target audience

For animal agriculture, primarily poultry integrators, growers, breeders, trade groups and allied industries; dairy and beef producers; livestock commodity groups; forage producers, equine owners, producers and interest groups; for crop and soils related research and extension programs, the audience includes existing and prospective grain crop producers, mixed (animal and crop production, e.g., dairy, horse) farms, crop commodity groups and trade associations, the "green industry" (e.g., horticulture, nurseries, landscapers), and certified crop advisors; for natural resource and ecology programs, private and not-for-profit organizations managing forests, wetlands, marshes, and other natural resource areas; state and federal agencies responsible for wildlife, forestry management, and coastal ecosystems; for our resource economic programs the audience includes farmers, landowners, policy-makers and state and federal agencies directly related to climate change policy (Delaware Development Office; Land Use Planning and Preservation; Department of Agriculture; Department of Health and Human Services; Department of Natural Resources & Environmental Control; Department of Transportation; Economic Development Office, USDA, NRCS, USEPA). For all programs, Delaware State Government and local legislators, homeowner associations, educators, community leaders, utility managers, retail stores distributing Energy Star products, fleet managers, building industry, Delaware Clean State Program members, Delaware Farm Bureau leaders, federal-state-local agriculture businesses, state and federal agencies; federal research laboratories; peer scientists in the U.S. and international colleagues, K-12 teachers, and environmental and community groups.

3. How was eXtension used?

In 2013 UD and DSU eXtension Institutional Team comprised of faculty and staff from across all planned program areas completed the following:

· Training on how to incorporate eXtension into grants
· Connected the Extension website with eXtension.org
· Implemented Ask an Expert throughout the state. Staff and faculty engaged in the eXtension Learn feature
· Faculty and staff increased participation in the Communities of Practice (COP)-DE is represented by 81 eXtension members in 43 of the 73 approved CoP
·

We trained 40 "experts" to use the Ask an Expert system and have fielded over 295 questions in the past 9 months. (84% of those questions were answered by Delaware experts). For Planned Program #7, we have two staff members actively involved in the Climate, Forests and Woodlands CoP. We also have 3 faculty involved in the Disaster Education Network that provides educational information with natural disasters related to climate. Also, when hurricane weather impacted Delaware last year, eXtension resources were culled to provide fact sheets to producers related to salt water on agronomic production lands. This information was readily available through the CoP within 24 hours of the storm. A fact sheet and web information were provided as well as links to other states information were provided to stakeholders.

V(E). Planned Program (Outputs)

1. Standard output measures

2013	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	16530	75877	2866	650

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	6	59	65

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of Competitive Grants Submitted

Year	Actual
2013	72

Output #2

Output Measure

- Number of Competitive Grants Awarded

Year	Actual
2013	36

Output #3

Output Measure

- Number of Research Projects Completed

Year	Actual
2013	68

Output #4

Output Measure

- Number of Undergraduate Researchers

Year	Actual
2013	62

Output #5

Output Measure

- Number of M.S. Graduate Students

Year	Actual
2013	45

Output #6

Output Measure

- Number of Ph.D. Graduate Students

Year	Actual
2013	25

Output #7

Output Measure

- Number of Post-doctoral Research Associates

Year	Actual
2013	13

Output #8

Output Measure

- Number of Refereed Journal Articles

Year	Actual

2013	65

Output #9

Output Measure

- Number of Books and Book Chapters

Year	Actual
2013	6

Output #10

Output Measure

- Number of Technical Reports

Year	Actual
2013	24

Output #11

Output Measure

- Number of Extension Bulletins and Factsheets

Year	Actual
2013	36

Output #12

Output Measure

- Number of Invited Presentations

Year	Actual
2013	105

Output #13

Output Measure

- Number of Volunteered Presentations

Year	Actual
2013	95

Output #14

Output Measure

- Number of Websites Established

Year	Actual
2013	16

Output #15

Output Measure

- Number of Workshops Conducted

Year	Actual
2013	157

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Educational programs for the poultry, livestock and equine industries on likely effects of climate change on animal health, productivity, the incidence of disease, greater energy costs due to warmer temperatures, and their management options to prevent new problems.
2	Greater awareness by farmers, the "Green Industry", other producers, and land managers of the types and possible magnitude of climate change impacts on crop production, with an emphasis on drought and irrigation management, increased incidences and diversity of pest pressures from insects, disease, and weeds, and nutrient cycling and transport for different crop rotations and tillage systems.
3	Outreach programs and demonstration projects on underlying principles and soil management programs now available to enhance carbon sequestration by agriculture, forestry, and other natural ecosystems (e.g., marshes, wetlands).
4	Educational programs for K-12 teachers, policy-makers, and the public on climate change and its potential effects on agriculture, natural ecosystems, and current and proposed approaches and new policies that could mitigate problems associated with climate change.
5	Increased number of poultry and livestock producers adopting management practices specifically designed to mitigate disease and animal health problems associated with climate change, particularly those related to year-round warmer conditions and weather extremes.
6	Increased number of crop producers adopting management practices specifically designed to mitigate plant growth problems associated with climate change, particularly those related to drought, pest pressures, and nutrient use.
7	Development of systematic strategies and plans to address climate change impacts on natural resource areas, particularly those related to plant species change, loss of biodiversity, wildlife ecology, and invasive plants.
8	Increased number of farmers, natural resource managers, and others aware of and participating in programs related to mitigating greenhouse gas emissions through programs such as carbon credits and carbon trading.
9	Greater scientific understanding of the fundamental mechanisms by which climate change affects plant and animal physiological processes, soil biological and chemical processes, and ecosystem health, with particular emphasis on challenges due to plant and animal diseases, water use efficiency, and biodiversity
10	Successful adoption of research-based management practices and economic policies that sustain animal agriculture, ensure crop productivity, protect or restore natural resource areas negatively impacted by climate change, and reduce greenhouse gas emissions.

Outcome #1

1. **Outcome Measures**

Educational programs for the poultry, livestock and equine industries on likely effects of climate change on animal health, productivity, the incidence of disease, greater energy costs due to warmer temperatures, and their management options to prevent new problems.

Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

Greater awareness by farmers, the "Green Industry", other producers, and land managers of the types and possible magnitude of climate change impacts on crop production, with an emphasis on drought and irrigation management, increased incidences and diversity of pest pressures from insects, disease, and weeds, and nutrient cycling and transport for different crop rotations and tillage systems.

Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

Outreach programs and demonstration projects on underlying principles and soil management programs now available to enhance carbon sequestration by agriculture, forestry, and other natural ecosystems (e.g., marshes, wetlands).

Not Reporting on this Outcome Measure

Outcome #4

1. **Outcome Measures**

Educational programs for K-12 teachers, policy-makers, and the public on climate change and its potential effects on agriculture, natural ecosystems, and current and proposed approaches and new policies that could mitigate problems associated with climate change.

2. **Associated Institution Types**

- 1862 Extension
- 1890 Extension

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)
Youths, teachers, policy makers, and the general public may not fully understand the potential effects of climate change.

What has been done
DSU?s Claude E. Phillips Herbarium educator has helped DSU gain certification as a Tree Campus of America and has led many programs to educate the public about natural resources and the environment. Activities have included campus-based tours of DSU?s Woodland Trail and Arboretum, as well as educational programs throughout the state. The educator stresses the importance of biodiversity and conservation, which are especially important in a changing climate.

Results
A total of 152 participants have increased knowledge via the Campus Nature Walks Program, Youth Botanical Tours, DSU class lectures, and invited off-campus weekend nature field trips.

4. Associated Knowledge Areas

KA Code	Knowledge Area
132	Weather and Climate
205	Plant Management Systems
307	Animal Management Systems
601	Economics of Agricultural Production and Farm Management
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

Outcome #5

1. Outcome Measures

Increased number of poultry and livestock producers adopting management practices specifically designed to mitigate disease and animal health problems associated with climate change, particularly those related to year-round warmer conditions and weather extremes.

Not Reporting on this Outcome Measure

Outcome #6

1. Outcome Measures

Increased number of crop producers adopting management practices specifically designed to mitigate plant growth problems associated with climate change, particularly those related to drought, pest pressures, and nutrient use.

2. Associated Institution Types

- 1862 Extension
- 1890 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
A changing climate can lead to decreased yields. It is important for farmers to be prepared by adopting management practices that can mitigate potential negative effects of climate change.

What has been done
New technologies and programs, geared toward increased profitability, have been introduced to small farm owners in Delaware. High tunnels offer farmers one such solution; they are relatively low in cost and can increase crop production when climates outside of the tunnels are intolerable.

Results
Four workshops and a conference were held, which focused primarily on high tunnels. One hundred seventy-six participants received information about high tunnels; more than 30 Delaware farmers have constructed new high tunnels in the last few years.

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
205	Plant Management Systems

601	Economics of Agricultural Production and Farm Management
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

Outcome #7

1. Outcome Measures

Development of systematic strategies and plans to address climate change impacts on natural resource areas, particularly those related to plant species change, loss of biodiversity, wildlife ecology, and invasive plants.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Citizens in Delaware and other mid-Atlantic states, state and federal agencies concerned about climate change impacts on state economic sectors and the need for strategies to address potential climate impacts

What has been done
A two-year effort to develop detailed climate change projections for Delaware (through 2100) was completed and used by a state task force to identify vulnerabilities of all major economic sectors (our focus was agriculture) to these new, detailed projections of climate change.

Results
A comprehensive study ("Delaware: Climate Change Impact Assessment") has been published and is being used to guide policies and inform education programs related to climate change. University of Delaware research and extension faculty contributed input and ideas to this study, particularly in the "Agriculture" and "Water Resources" sections. UD extension programs and new research projects are using this information to educate citizens, agricultural and environmental groups, and granting agencies about actions and new research studies now needed.

4. Associated Knowledge Areas

KA Code	Knowledge Area
132	Weather and Climate
136	Conservation of Biological Diversity
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

Outcome #8

1. Outcome Measures

Increased number of farmers, natural resource managers, and others aware of and participating in programs related to mitigating greenhouse gas emissions through programs such as carbon credits and carbon trading.

Not Reporting on this Outcome Measure

Outcome #9

1. Outcome Measures

Greater scientific understanding of the fundamental mechanisms by which climate change affects plant and animal physiological processes, soil biological and chemical processes, and ecosystem health, with particular emphasis on challenges due to plant and animal diseases, water use efficiency, and biodiversity

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Natural resource managers, water quality agencies and groups concerned about impacts of extreme storms on stream runoff export of dissolved carbon from forested watersheds and resultant impacts on aquatic ecology

What has been done
Field research quantified stream runoff exports of particulate and dissolved organic carbon from a 12 ha forested watershed from a wide range of storm events varying in severity, including three

extreme events associated with Hurricanes Nicole, Irene, and Sandy.

Results

Findings from the study showed that POC and DOC exports from small events were comparable but that runoff following extreme events increased 6-8 fold; in one year, Hurricane Irene events alone accounted for 56% and 12% of annual POC and DOC losses. Results from the study led to the identification of a precipitation threshold value above which POC losses increased markedly compared to DOC losses. In general, the study showed that important differences exist in POC and DOC losses due to temporal and hydrologic variability with extreme events identified as being highly important in carbon export from forests to streams to downstream waters. Given the predicted increase in extreme events due to climate change, developing accurate models of C loss is critical to protect ecosystem and human health.

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
136	Conservation of Biological Diversity
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
205	Plant Management Systems
305	Animal Physiological Processes
307	Animal Management Systems
311	Animal Diseases

Outcome #10

1. Outcome Measures

Successful adoption of research-based management practices and economic policies that sustain animal agriculture, ensure crop productivity, protect or restore natural resource areas negatively impacted by climate change, and reduce greenhouse gas emissions.

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

{No Data Entered}

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Evaluation of the Climate Change planned program shows growing activity in research and extension in this area as faculty and extension professionals have begun to incorporate a range of aspects on climate change into existing projects and launch new studies where climate change impacts are a central component. A total of 36 grants supported the efforts of 145 graduate students, post-docs, and undergraduate researchers who conducted studies in areas that would be affected by expected changes in future climates. Similarly, 65 refereed journal articles, 200 invited and volunteered presentations, and 157 workshops were completed in areas where climate change impacts must be considered more carefully in the future. Our evaluations suggest that farmers, land managers, state and federal agencies, environmental groups, and the public value efforts to determine how current priority areas for research in Delaware may be affected by the anticipated changes in future climate

Key Items of Evaluation

There are no major items requiring NIFA attention at this time, other than the continued need for more federal funding for research and extension programs that seek to incorporate potential climate change impacts into current and planned projects on areas of high priority to Delaware.