

V(A). Planned Program (Summary)

Program # 2

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
101	Appraisal of Soil Resources	10%		5%	
102	Soil, Plant, Water, Nutrient Relationships	10%		5%	
103	Management of Saline and Sodic Soils and Salinity	5%		0%	
111	Conservation and Efficient Use of Water	10%		5%	
123	Management and Sustainability of Forest Resources	5%		5%	
132	Weather and Climate	10%		3%	
133	Pollution Prevention and Mitigation	6%		20%	
141	Air Resource Protection and Management	5%		5%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants	6%		11%	
206	Basic Plant Biology	5%		5%	
306	Environmental Stress in Animals	6%		10%	
603	Market Economics	7%		5%	
605	Natural Resource and Environmental Economics	7%		5%	
608	Community Resource Planning and Development	8%		16%	
	Total	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	5.1	0.0	18.7	0.0
Actual Paid Professional	8.9	0.0	25.9	0.0
Actual Volunteer	9.6	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
370068	0	599068	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
820825	0	1737415	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
517885	0	1553868	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Programs will address the full breath of climate change sciences spanning physical, biological, and social uncertainties, risks, and responses--those that are underway as well as those on the frontier. Robust research and extension will foster interdisciplinary, multifunctional teams and approaches that will link multiple institutions and span, connect, and garner resources that can measure, forecast, and specify the complexities of climate change in context to priority sectors, including water quality and quantity, air quality (greenhouse gas emissions, carbon sequestration in working lands), risk assessment, and decision-making, as well as the emerging paradigms for sustainable agriculture and forestry.

Research and extension will support carbon sequestration, mitigation of greenhouse gases, and development of science-informed policies for supporting management of multifunctional working lands with enhancement of the ecosystem services they can provide. Furthermore, the stresses of change on biodiversity from the molecular through population levels will be critically addressed within this approach. Interdisciplinary, multifunctional teams are essential to the identification of critical gaps and for addressing the emerging frontiers within climate change that will enable the integrated approaches necessary for addressing the complexities of climate change.

The issues and impacts that PA AES and CES will address through research and outreach include climate change uncertainties, risk management, climate futures and forecasts, water resources, forests and wildlife, aquatic ecosystems and fisheries, agriculture production and insurance, energy, and economic barriers and opportunities. Research and extension emphasis will be placed on forecasts, impacts, and regional vulnerabilities for agriculture, forests, and human populations, as well as decision-making tools for adaptive management by sector.

2. Brief description of the target audience

- Agricultural Producers/Farmers/Landowners
- Agriculture Services/Businesses
- Nonprofit Associations/Organizations
- Business and Industry
- Community Groups
- Education

- General Public
- Government Personnel
- Students/Youth
- Volunteers/Extension Leaders

3. How was eXtension used?

Members of most teams serve as topic experts and answer questions from participants of the ask the expert program.

The eXtension website was regularly used to locate research-based information for water quality, well, and on-lot sewage disposal system management to provide to clientele.

On the horticulture team, some members used eXtension for professional development; some referred clients to obtain information; and others used it for the development of online courses. Many green industry sub-team members are concerned with the utility of eXtension for extension educational programs.

V(E). Planned Program (Outputs)

1. Standard output measures

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	18	0	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of college-initiated technology disclosures.

Year Actual

2013 0

Output #2

Output Measure

- Number of participants in extension education classes and workshops.

Year	Actual
2013	13941

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Percentage of extension class/workshop participants who expect to implement/adopt practices. (This is a short-term outcome measure.)
2	Percentage of extension class/workshop participants who respond to a follow-up survey with a self-report that they have implemented/adopted practices. (This is a medium-term outcome measure.)
3	New drought vulnerability assessment tool for PA that accounts for soil variability and corn's sensitivity to soil moisture deficit during critical stages of crop development.
4	Linkage of models to assess how changes in labor supply due to climate change-related migration may affect the regional magnitude of migration.
5	Investigation of how simulated expected future climate conditions may affect the future state of recently harvested forests.
6	Investigation of previously unstudied traits that make essential crops more drought tolerant.
7	Analysis of private sector role in greening the agro-food chain.
8	Development of first empirically based model estimating fine root lifespan and turnover, providing an important tool in efforts to accurately model the effects of future climate change.

Outcome #1

1. Outcome Measures

Percentage of extension class/workshop participants who expect to implement/adopt practices. (This is a short-term outcome measure.)

Not Reporting on this Outcome Measure

Outcome #2

1. Outcome Measures

Percentage of extension class/workshop participants who respond to a follow-up survey with a self-report that they have implemented/adopted practices. (This is a medium-term outcome measure.)

Not Reporting on this Outcome Measure

Outcome #3

1. Outcome Measures

New drought vulnerability assessment tool for PA that accounts for soil variability and corn's sensitivity to soil moisture deficit during critical stages of crop development.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Many farmers are unaware of long-term historic drought conditions, their vulnerability to crop losses, or how climate change may increase their vulnerability. Agricultural drought occurs when soil moisture can't meet plants needs and crop yields fall. An accurate drought vulnerability assessment accounts for soil variability and crop sensitivity to soil moisture deficit during critical stages of crop development. Many drought indices now used do not meet these criteria.

What has been done

This research developed a field-scale long-term agricultural drought risk assessment tool for corn growers in PA. The tool requires limited data to allow wide implementation.

The effects of soil moisture stress on corn production were quantified along with the vulnerability of PA's soils to agricultural drought under various climatic conditions. A drought vulnerability index representing conditions likely to occur once every 4 years was mapped over 9 PA counties and related to yield reductions.

Results

Drought is the primary contributor to crop failure in the U.S., resulting in estimated annual losses of more than \$5 billion. USDA estimated that the 1999 drought caused \$500 million in crop losses in PA, and in some counties crop losses were 70-100%.

This study showed that the drought vulnerability of a location stems from the complex interaction of climate and soil properties.

More than half the study area will likely experience drought-related relative corn yield reductions between 80 and 100% in 1 of every 4 years. Drought vulnerability mapping, which helps farmers determine if they should purchase crop insurance, is an aspect of PaOneStop (<http://paonestop.org>), which allows farmers to map features important to planning. The system's 2,000+ users have mapped more than 12,000 farms.

Numerous workshops and other events will be conducted to extend this information to user groups, and website use has been monitored and tracked.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
102	Soil, Plant, Water, Nutrient Relationships
111	Conservation and Efficient Use of Water

Outcome #4

1. Outcome Measures

Linkage of models to assess how changes in labor supply due to climate change-related migration may affect the regional magnitude of migration.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
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2013

1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Future climate change is expected to drive migration of people north to escape more extreme heat. Previous models of climate change-related migration have not accounted for changes in labor wages as a result of migration. Having an accurate understanding of expected future social patterns related to climate change, such as choice of household location, will allow society to better plan for and adapt to those changes.

What has been done

This study linked a model of location choice with a model of regional economic activity to account for how changes in the supply of labor due to migration may affect the regional magnitude of migration.

Results

Extreme temperatures and precipitation reduce people's preference for a location. This study found that predicted future changes in climate will result in greater migration to the Northeast from the South due to fewer extremely cold days in the North and more extremely hot days in the South. The Northeast's gross regional product (GRP) is forecasted to increase by 3.4%, while the South's GRP drops by 2.1% when climate change-induced migration is compared with the baseline scenario -- business as usual -- in the year 2065. Accounting for labor wages dampens regional economic impacts from climate change-induced migration. Wage effects tend to dominate climate effects on household location choice. The results suggest that ignoring feedback from the labor market overestimates climate change-related migration and its economic impacts. Having accurate models of expected future responses to climate change will allow society to better plan for its effects.

4. Associated Knowledge Areas

KA Code	Knowledge Area
132	Weather and Climate
608	Community Resource Planning and Development

Outcome #5

1. Outcome Measures

Investigation of how simulated expected future climate conditions may affect the future state of recently harvested forests.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Pennsylvania and the Northeast rely on forests to deliver ecosystem services such as providing wood, cleaning the air and water, and sustaining wildlife. Research suggests that the composition and function of these ecosystems will change as the climate warms.

What has been done

Field experiments examined how simulated expected future climate conditions may affect the trajectory that a recently harvested forest takes. Experiments examined effects on (i) the soil carbon and nitrogen cycles, (ii) plant and soil microorganism populations, and (iii) forest microclimate measures such as growing-degree days and frost-free days.

Results

These experiments showed that ecosystem responses to predicted changes in climate are so complex that it is unrealistic to think about the reaction of an individual plant species. This research emphasizes the importance of competition for resources among species, and shows that biotic interactions drive northeastern forest dynamics. Indirect impacts on species interactions trump direct impacts on species of predicted increases in temperature and precipitation. Accurate future models really must account for microclimatic effects as well, such as changes in number of growing-degree days and frost-free days. Therefore, accurate modeling of expected climate change effects on northeastern forests is more difficult and complicated than previously thought.

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources
132	Weather and Climate

Outcome #6

1. Outcome Measures

Investigation of previously unstudied traits that make essential crops more drought tolerant.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Climate change is expected to degrade soil quality and fertility because more extreme rainfall events will mean more drought and more erosion. Developing crop lines that are more drought tolerant and efficient in acquiring nitrogen will help to reduce hunger and water pollution and increase crop production efficiency. Nitrogen fertilizer is the largest input cost for corn production, and its manufacture and use causes greenhouse gas emissions and water pollution.

What has been done

Penn State researchers and partners are identifying previously unstudied traits that make essential crops more drought tolerant. They applied for a patent on laser ablation tomography (LAT) to replace a laborious process of preparing root samples for phenotype analysis. LAT allows researchers to easily examine traits, such as cortical cell file number and size, that increase drought tolerance. The team is identifying the genes controlling those traits, which will facilitate crop breeding.

Results

Plant roots are the key to making plants more drought resistant. This work is identifying ways to make roots function more efficiently in important crops such as corn and common bean--staple foods in the diet of millions of people around the world--thereby increasing yield. The researchers would also expect to find similar increases in yield under drought in cereal crops when these previously unstudied traits are selected for in breeding.

This research aims to make agricultural production systems more resilient to climate change and to produce more food in an environmentally sensitive manner. This will ensure access to nutritious and safe foods and address the emerging challenges of climate change and natural resource scarcity.

Having corn varieties that acquire nitrogen more efficiently will reduce fertilizer costs, thereby increasing profitability, and reduce air and water pollution. These advances will also decrease the environmental costs of driving cars because about half of the corn grown in the U.S. is now used for fuel.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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102	Soil, Plant, Water, Nutrient Relationships
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants

Outcome #7

1. Outcome Measures

Analysis of private sector role in greening the agro-food chain.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

By 2050 the world's population is expected to be roughly one-third higher than today, and global average demand for meat will increase more than 20%, due to growth in emerging markets. This growth, coupled with the potential effects of climate change, will increase pressure on agriculture, on natural resources, and on environmental quality. There will be increasing interest in programs that balance the desire for abundant food at reasonable prices against the desire to preserve the environment.

What has been done

A Penn State researcher identified incentives for the private sector to help in greening the agro-food industry, both with inputs to farmers and with processing and sales of farm products. He examined energy and water use, green labeling, and product waste, among other topics.

Results

The researcher concluded that there are many incentives for the food industry to reduce its environmental footprint, the greatest being that the prices of many inputs are rising. He noted that government standardization of green labeling, such as "climate-friendly," could help this process along, just as it has for certified organic products. With standardization of green labeling, consumers could trust that they were getting a certain quality of product, and some consumers would be willing to pay a premium for that. Companies embrace standardized labeling because it allows them to differentiate their products.

4. Associated Knowledge Areas

KA Code	Knowledge Area
603	Market Economics
605	Natural Resource and Environmental Economics

Outcome #8

1. Outcome Measures

Development of first empirically based model estimating fine root lifespan and turnover, providing an important tool in efforts to accurately model the effects of future climate change.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Root responses to environmental conditions can have a major influence on plant growth and production, the carbon and water cycles, and ecosystem services. Yet we have only very limited understanding of root function under field conditions. Climate change will strongly influence and be influenced by terrestrial carbon and water fluxes, a significant fraction of which is associated with root water uptake, root turnover, and root respiration.

What has been done

Penn State researchers combined species-specific estimates of fine root dynamics with a model that predicts current distribution and future suitable habitat of temperate tree species across the eastern U.S. Estimates of fine root lifespan and turnover are based on empirical observations and relationships with fine root and whole-plant traits. The estimates apply explicitly to the fine root pool that is relatively short-lived and most active in nutrient and water uptake.

Results

Results from the combined model identified patterns of faster root turnover rates in the north central U.S. and slower turnover rates in the southeast U.S. Parts of MN, OH, and PA were predicted to experience >10% increases in root turnover rates given potential shifts in tree species composition under future climate scenarios, while root turnover rates in other parts of the East were predicted to decrease. Despite potential regional changes, the average estimates of root lifespan and turnover for the study area remained relatively stable between current and future climate scenarios.

The model provides the first empirically based and spatially explicit and extensive estimates of fine root lifespan and turnover. It is a potentially powerful tool allowing researchers to identify reasonable approximations of forest fine root turnover where no direct observations are available. The model is important as researchers attempt to more accurately model the effects of future climate change.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
123	Management and Sustainability of Forest Resources
206	Basic Plant Biology

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Competing Public priorities
- Competing Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)
- Other (Extramural Funding)

Brief Explanation

Natural Disasters (drought, weather extremes, etc.)

- Adverse weather factors continue to influence clientele participation, both from extended periods of rain in summer and winter snow and ice events.

Economy

- The economic climate continues to have a significant impact on the ability of clientele to attend meetings and conferences.

Appropriations changes

- Appropriation Changes affected both the research and extension functions of the College of Agricultural Sciences and resulted in fewer faculty and staff across all areas of the college.

Competing Public priorities

- Competing Public Priorities force us to continually align our program priorities with budget realities.

Competing Programmatic Challenges

- The College of Agricultural Sciences' restructuring process allowed for continued focus on cost-effective program deliverables and strategic elimination of programs.

Other - Extramural Funding

- Some of our programs are affected by extramural funding, either by adding resources to promote them or by shaping the content of the product.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The generation of outcomes from existing programs and the development of new programs require improved evaluation that identifies pre- and post- responses to information and monitoring for long-term behavioral changes that result in improved environmental outcomes. The evaluations conducted thus far provide initial measures of implementation, but long-term monitoring is needed to ensure that the practices are successfully managed over time. We are attempting to incorporate more economic valuations of the results of our research and extension work.

Key Items of Evaluation

See highlights of state-defined outcomes in this planned program.