V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Environmental Resilience

☑ 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	2%		6%	
102	Soil, Plant, Water, Nutrient Relationships	13%		10%	
112	Watershed Protection and Management	7%		10%	
121	Management of Range Resources	8%		2%	
123	Management and Sustainability of Forest Resources	8%		11%	
132	Weather and Climate	0%		3%	
133	Pollution Prevention and Mitigation	7%		9%	
134	Outdoor Recreation	8%		2%	
135	Aquatic and Terrestrial Wildlife	5%		13%	
136	Conservation of Biological Diversity	0%		3%	
201	Plant Genome, Genetics, and Genetic Mechanisms	0%		4%	
212	Diseases and Nematodes Affecting Plants	4%		8%	
213	Weeds Affecting Plants	7%		5%	
301	Reproductive Performance of Animals	4%		2%	
302	Nutrient Utilization in Animals	9%		3%	
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals	4%		2%	
605	Natural Resource and Environmental Economics	2%		4%	
610	Domestic Policy Analysis	4%		1%	
611	Foreign Policy and Programs	4%		1%	
723	Hazards to Human Health and Safety	4%		1%	
	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	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}	{NO DATA ENTERED}
Actual Paid	9.8	0.0	13.5	0.0
Actual Volunteer	24.0	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
1718808	0	1990487	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
2342277	0	5889432	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
1898103	0	10601935	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Environmental quality is affected by a broad spectrum of activities on the terrestrial and aquatic landscapes, including agricultural practices, natural gas drilling, forest resource management, wildlife and fisheries management, land use decisions, population dynamics, and recreation--all of which will likely be influenced by climate change. Research and extension programs focus on the protection, enhancement, and restoration of environmental resources to develop sustainable management approaches for the use and preservation of these fragile resources. The management of our natural resources can have direct and substantial influences on environmental outcomes. In the agricultural sector, producers manage soil resources, balance nutrients, and protect air and water quality, while maintaining production efficiencies as environmental regulations are being more stringently enforced.

Pennsylvania has significant forest resources, 70% of which are under private ownership; the balance is under state, federal, or industry control. The economics of land use and balancing timber production with recreation, wildlife management, environmental degradation, and land development pressure are critical issues facing forest landowners in the state. Local and state governments and nongovernmental organizations in partnerships with AES and CES work together to develop and implement policies based on science for the effective management of natural resources and protection of the environment.

A key demand for research and extension programming is nutrient management, including economic trade-offs and considerations at farm, watershed, and regional scales. Addressing tillage practices in sequence with innovations in manure application, regional waste-to-energy technologies, and effects on water quality are included in our programming portfolio. Implementation of integrated pest management programs is an important component necessary to develop sustainable management approaches for

environmental protection. A wide range of natural resource management activities focuses on forest management for timber production, recreation, fish and wildlife management, economics of natural resource management practices, and land use decision-making. Extension programs also address community and urban natural resource management.

2. Brief description of the target audience

Agricultural Producers/Farmers/Landowners
Agriculture Services/Businesses
Nonprofit Associations/Organizations
Business/Industry
Community Groups
Education
General Public
Government Personnel
Local, Regional, State, and Federal agencies
Military
Non-Governmental Organizations
Nonprofit Associations/Organizations
Policy Makers
Special Populations (at-risk and underserved audiences)
Students/Youth
Volunteers/Extension Leaders

3. How was eXtension used?

Penn State Cooperative Extension supports faculty and staff use of eXtension and promotes communities of practice as a way of broadening sources of information and outreach. Penn State Cooperative Extension supports the professional development offered through eXtension.org. Some members of most teams serve as topic experts and answer questions from participants of the Ask the Expert program.

The team members of the Penn State Equine Extension Stewardship Program are listed on the Ask the Expert eXtension program. One member serves on the Federal eXtension web-based program, USDA Extension, Horse QuestNational Equine Resource Team. In addition, members of the PSU equine team are on USDA Experiment Station Project No. 1141, which works very closely with the Equine Horsequest eXtension project. One team member, through the Equine Environmental Impact MultiState Experiment Station Project, is part of the planning committee of the Waste to Worth eXtension Program to be held in April 2015.

A member of the soils extension team worked with the eOrganic community of practice on eXtension to present webinars and develop fact sheets.

V(E). Planned Program (Outputs)

1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	26957	508704	5759	2467

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	28	157	185

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of participants in extension education classes and workshops.

Year	Actual
2014	27833

Output #2

Output Measure

- Number of technology disclosures involving college faculty, staff, extension educators, or students.

Year	Actual
2014	0

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Estimated value (in $M) of avoided loss in recreational use values of coral reefs in Hawaii from 2000 to 2100 if a greenhouse gas mitigation policy scenario involving full international participation in reducing emissions is adopted, versus a business as usual emissions scenario.
2	Determination that land application of wastewater is more effective for removal of some estrogenic chemicals than is direct stream discharge.
3	Candidate genes for blight resistance in Chinese chestnut tree identified to aid restoration of American chestnut.
4	Global dose-response curves developed for the herbicides dicamba and 2,4-D on cotton and soybean using data from more than 70 years of simulated drift experiments.
5	Number of major habitat types at greatest risk from development of shale oil and gas resources in the United States.
6	Finding that unconventional shale gas development may cause measurable changes in soil function.
7	Potential annual cost savings (in $) if 10% of attendees of PSU equine owners' educational programs adopted proper ration balancing.

Outcome #1

1. Outcome Measures

Estimated value (in $M) of avoided loss in recreational use values of coral reefs in Hawaii from 2000 to 2100 if a greenhouse gas mitigation policy scenario involving full international participation in reducing emissions is adopted, versus a business as usual emissions scenario.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	10600

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The ecosystem services provided by coral reefs are highly vulnerable to increasing atmospheric and ocean carbon dioxide concentrations. The net annual value of the services provided by coral reefs globally has been estimated at approximately $33.6 billion per year, with tourism and recreation accounting for $10.8 billion (all values adjusted to US 2007$).

What has been done
The researchers applied the COMBO coral reef simulation model to shallow-water reefs in Hawaii, Florida, and Puerto Rico. They compared estimates of future coral cover from 2000 to 2100 for a 'business as usual' greenhouse gas (GHG) emissions scenario with a GHG mitigation policy scenario involving full international participation in reducing GHG. They calculated the economic value of changes in coral cover, including recreational values for snorkeling and diving and existence values for reefs.

Results
Results suggest that a reduced emissions scenario would provide a large benefit to shallow water reefs in Hawaii by delaying or avoiding potential future bleaching events. For Hawaii, reducing emissions is projected to result in an estimated "avoided loss" from 2000 to 2100 of approximately $10.6 billion in recreational use values compared to a BAU scenario. However, in Puerto Rico and South Florida, sea-surface temperatures are already close to bleaching thresholds and coral cover is projected to drop well below 5% cover under both scenarios by 2050, and below 1% cover under both scenarios by 2100. The work appeared in the journal PLOS One.

The results indicate the grave changes that can be expected with climate change. Without strong

tourism spending, the economies of these places and places like them would be devastated and they would require more federal assistance.

4. Associated Knowledge Areas

KA Code	Knowledge Area
132	Weather and Climate
134	Outdoor Recreation
136	Conservation of Biological Diversity
605	Natural Resource and Environmental Economics
610	Domestic Policy Analysis
611	Foreign Policy and Programs

Outcome #2

1. Outcome Measures

Determination that land application of wastewater is more effective for removal of some estrogenic chemicals than is direct stream discharge.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Birth control medication may be discarded in the sewer system. Treated wastewater is sometimes applied as irrigation water to forest and/or cropland. The movement of endocrine-disrupting chemicals (EDC) through the soils of these systems is not well understood, nor is their effect on human and animal health. Estrogenic compounds have been found in U.S. surface waters, and they are known to feminize male fish and destroy fish populations.

What has been done
Do EDCs in wastewater used for irrigation accumulate in soil above the water table, effectively keeping them out of groundwater and reducing fish exposure to these chemicals? At Penn State's "Living Filter" site, researchers measured levels of 3 estrogenic compounds - 2 naturally produced hormones and 1 synthetic component of birth control pills - in the soils of wastewater-irrigated

forestland, cropland, and a non-irrigated control site. The work appeared in the Journal of Environmental Quality.

Results
Soil from wastewater-irrigated sites contained higher concentrations of the 2 natural hormones than did control site soil. Concentrations of the synthetic chemical were generally near detection limits at all sites. But accumulation of EDCs in soil depended on land use. Forested soils accumulated more EDCs than did agricultural soils. In forest soils, which have about 3 times as much organic carbon as agricultural soils, EDCs bind to the organic carbon and don't move as rapidly through the soil. Land application of wastewater is more effective for removal of these estrogenic chemicals than is direct stream discharge. But effluent management practices may need to be adjusted to account for soil accumulation of some of these chemicals. The scientists are now measuring EDC concentrations in wells near the Living Filter to see if soil accumulation prevents EDCs from entering groundwater. In the future, experts expect to see more wastewater used for irrigation and groundwater recharge.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation
301	Reproductive Performance of Animals
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals
723	Hazards to Human Health and Safety

Outcome #3

1. Outcome Measures

Candidate genes for blight resistance in Chinese chestnut tree identified to aid restoration of American chestnut.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	12

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The American chestnut, a tree that in its time was highly versatile and prevalent, is struggling from its long battle with chestnut blight. The fungus came to America through imports from Asia. The earliest case was cited in 1904, and by the 1950s, nearly every tree was infected. Today, roots in the forest still sprout new shoots, which succumb to infection. This work addresses restoring American chestnut through transfer of blight resistance genes from Chinese chestnut by back-cross breeding.

What has been done
The researchers have assembled over 90% of the Chinese chestnut genome, including three regions (loci) in the genome responsible for blight resistance. Having a sequenced genome helps to further research and breeding for blight resistance. They have identified and are testing about a dozen candidate genes for their roles in blight resistance. All twelve, or more, may be involved.

Results
The researchers are already using the genome sequence to follow variation across the genome to advance the breeding and selection process while they also determine which specific genes are most important to blight resistance. A website for the genome has been established, with public access. The journal Tree Genetics and Genomes carried the paper.

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources
201	Plant Genome, Genetics, and Genetic Mechanisms
212	Diseases and Nematodes Affecting Plants

Outcome #4

1. Outcome Measures

Global dose-response curves developed for the herbicides dicamba and 2,4-D on cotton and soybean using data from more than 70 years of simulated drift experiments.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Commercial introduction of soybean, corn, and cotton genetically engineered to resist the herbicides dicamba and 2,4-D will increase the flexibility of these herbicides, but may cause problems related to herbicide drift with susceptible soybean and cotton.

What has been done
The researchers conducted a meta-analysis using data from more than 70 years of simulated drift experiments in which soybean and cotton were treated with low doses of these herbicides and yields were measured. The researchers produced global dose-response curves for each crop and herbicide.

Results
Soybean is more susceptible to dicamba in the flowering stage and relatively tolerant to 2, 4-D throughout its growth. The results are nearly opposite for cotton, with greatest vulnerability to dicamba in the vegetative and preflowering squaring stages. Both crops show variability in their response to these herbicides. Soil moisture and air temperature at time of exposure are critical. Visual injury symptoms, especially during vegetative stages, do not predict final yield loss. The global dose-response curves generated through this work can guide herbicide applications and approximate the mean and range of crop yield loss expected as a result of drift or nontarget exposure to dicamba or 2, 4-D. The article was chosen as paper of the year in the journal Weed Science.

4. Associated Knowledge Areas

KA Code	Knowledge Area
213	Weeds Affecting Plants

Outcome #5

1. Outcome Measures

Number of major habitat types at greatest risk from development of shale oil and gas resources in the United States.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual

2014 3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The widespread use of hydraulic fracturing and horizontal drilling has opened up new shale oil and gas plays across the U.S. in recent years. Full build-out of these resources is not expected for years. Other countries as well are similarly beginning to develop these resources. The stages of resource exploration, development, and production affect nearby ecosystems. Some impacts are likely to be similar to those from conventional energy extraction, but some are relatively uncharted.

What has been done
In the Lower 48 states, 20 shale plays are under extensive development and production. The research team reviewed the literature on the ecological effects of conventional oil and gas extraction on habitat and wildlife. They also noted differences related to hydraulic fracturing and horizontal drilling, such as accidental release of wastewater, that could be detrimental to wildlife and habitats.

Results
The researchers concluded that species and habitats most at risk are ones where there is a great deal of overlap between the shale resource and a species' range or a habitat type, and for which there is also limited range, low population size, special habitat requirements, and/or high sensitivity to disturbance. Examples of these at-risk habitat types and species include core forest and core forest specialists; sagebrush habitat and specialists; and vernal ponds, species that require vernal ponds, and stream biota. The team suggests concentrating research and monitoring on spatial analyses, species-based modeling, vulnerability assessments, ecoregional assessments, and threshold and toxicity evaluations to help with development of guidelines and policies to reduce negative effects of shale energy exploration and development and to protect sensitive species and ecosystems.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
123	Management and Sustainability of Forest Resources
135	Aquatic and Terrestrial Wildlife
136	Conservation of Biological Diversity

Outcome #6

1. Outcome Measures

Finding that unconventional shale gas development may cause measurable changes in soil function.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Development of historical conventional gas and recent unconventional shale-gas infrastructure in Appalachia has led to extensive landscape disturbance. For each of more than 1,500 well pads constructed in Pennsylvania thus far, about two hectares of soil per pad are typically removed, stockpiled, and eventually reclaimed. Researchers hypothesized that unconventional gas development would cause measurable changes in soil function.

What has been done
To test this hypothesis, they examined dynamic soil property (DSP) change on three types of reclaimed gas infrastructure: 75-year-old conventional gas pads, 25-year-old conventional gas pads, and recently developed unconventional gas pads. Disturbed and undisturbed soils within a site were analyzed for bulk density, soil organic carbon (SOC) pools, soil nitrogen (N) pools, and available phosphorus pools.

Results
Results showed that conventional sites do not currently exhibit significant differences in DSPs between disturbed and undisturbed soils, but unconventional sites show significantly higher (potentially root-limiting) bulk density and lower SOC and N pools on disturbed soils. The team attributed the significant DSP change on unconventional sites to soil compaction during reclamation surface grading and increased soil organic matter decomposition, N mineralization, and soil mixing during stockpiling. The 75- and 25-year-old conventional sites probably exhibit less DSP change now because more time has passed during which these soils could recover.

Reclaimed soils on unconventional sites under the conditions in this study are unlikely to be as productive as adjacent undisturbed soils. Techniques developed for mine soil reclamation may be applicable to unconventional gas sites, but further analysis of their effectiveness and economic benefits specific to natural gas development is needed.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources

102	Soil, Plant, Water, Nutrient Relationships
123	Management and Sustainability of Forest Resources

Outcome #7

1. Outcome Measures

Potential annual cost savings (in $) if 10% of attendees of PSU equine owners' educational programs adopted proper ration balancing.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	1400000

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Routine overfeeding of dietary protein and phosphorus results in significant nutrient losses in manure. Previous journal articles showed that protein and phosphorus levels in equine rations averaged 62% and 92%, respectively, above National Research Council (2007) recommendations. This inefficiency costs owners in unnecessary feed costs and society in nutrient pollution to waterways.

What has been done
The researchers evaluated rations on 23 equine farms. They reformulated rations using NRC recommendations.

Results
The continued use of NRC-recommended ration balancing would reduce nutrient loads to the state's watersheds. Reducing feed (8-10 lbs of grain/concentrates @ $15/50 lb. bag, to 4-5 lbs and increased forage) would save farms an average of $219/equine/year. If just 10% of attendees of PSU equine owners' educational programs adopted proper ration balancing, the yearly savings in feed costs could be $1.4 million. Annual nutrient loading would be reduced by 19.5 tons N and 5.6 tons P.

The equine industry is the second largest animal agricultural industry in PA and directly accounts for over $10 billion of economic activity. Equine owners devote 1.14 million acres of land in the state to equine purposes, with associated assets totaling nearly $8.27 billion. The equine industry

provides about 20,000 jobs to the Commonwealth.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
302	Nutrient Utilization in Animals

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
- Other (Extramural Funding)

Brief Explanation

Natural Disasters

- Weather conditions may drive clients' requests for programs.
- Weather conditions may necessitate changes in field research plans.

Economy

- The economy influences the ability of clientele to implement tactics suggested.
- Limited budgets for travel do not allow educators to meet all requests for educational programs.

Appropriations Changes

- The decrease in public support for both research and extension, as measured by real dollars, has necessitated a shift by research and extension teams to more extramural funding.

Government Regulations

- Government regulations can provide funding to train technical service providers in the Mid-Atlantic region or can drive the demand for programs.

Competing Public Priorities

- Competing public priorities force us to continually align our program priorities with budget realities.
- Youth program offerings compete against their various other activities.

Competing Programmatic Challenges

- With the continued loss of county-based FTEs in some programs, it is difficult to provide a comprehensive statewide program.
- Demand from external partners for subject matter expertise consumes educator resources.

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.
- Extramural funding has allowed some teams to conduct practical applied research projects that include integrated extension/educational components.

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 outcomes. More statewide extension programs are using retrospective evaluation to gather information about the number of participants who actually put into practice lessons learned through extension programs. Measuring costs averted or profit increased can show powerful, tangible benefits of our programming--the type of feedback that keeps people coming back for more information. Customer satisfaction and needs assessment instruments (Salesforce and Atlas) are scheduled to be implemented in fall 2015 to provide feedback on the quality and value of our programs.

Key Items of Evaluation

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