2018 Pennsylvania State University Combined Research and Extension Annual Report of Accomplishments and Results

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I. Report Overview

1. Executive Summary

Penn State's Agricultural Experiment Station (AES) and Cooperative Extension Service (CES) operate in concert within the College of Agricultural Sciences to address present and future needs in agriculture at local, state, national, and international scales.

Our faculty strive to conduct research that will provide solutions to the most pressing challenges to growers, producers, industry, and other stakeholders, and to team with extension personnel to transfer new knowledge and innovations into the field where they can make a measurable difference in the bottom line.

Penn State's College of Agricultural Sciences saw a 7 percent increase in research expenditures in fiscal year 2017-2018, to $121 million. We leverage NIFA funding and Hatch funds salary support with those dollars to multiply our impacts.

Continuing focus on entrepreneurship. The college's and university's trend toward encouraging entrepreneurship is continuing and growing. The college hired a research commercialization leader with expertise in helping researchers and startups successfully navigate commercialization. We started a faculty learning community interested in advancing global knowledge through new methodologies and technologies.

A new biobased treatment for bedbugs developed by Penn State entomologists saw strong sales from pest application professionals in its first year on the market. Another team is working on sustainable, biologically derived materials created using polysaccharides with potential applications in sustainable packaging, construction materials, food products, and biomaterials for health care.

The fight again spotted lanternfly. Interdisciplinary efforts to fight the invasive spotted lanternfly include public education; study of its genetic markers to estimate the effective size of the current population, track population growth and movement, and detect subsequent invasions; assessment of its microbiome to determine whether it transmits bacterial or fungal pathogens to plants through feeding; and observation of its mating and dispersal patterns. Spotted lanternfly could damage Pennsylvania's $18 billion wine, tree fruit, hardwood, and/or nursery industries. Similar efforts are underway against numerous other invasive insects that could bring serious economic hardship to important agricultural industries.

Planned Programs. Our research efforts, as outlined in the College's 2014-2019 strategic plan, fall into the planned programs below. The planned programs are dynamic and allow for the development and integration of new scientific approaches. Departmental annual reviews and strategic plans, as well as their signature research areas, also inform the planned programs.

Advanced Agricultural and Food Systems-Transforming thinking and practice in agricultural and food systems through research and extension programming focused on productivity, sustainability, and adaptability.

Biologically Based Materials and Products-Discovering novel approaches to using genetic systems and biological materials for value-added commercial and consumer products. Laying the groundwork for biobased energy and industries in Pennsylvania.

Community Resilience and Capacity-Helping communities improve their economic resilience, create sustainable infrastructures, and promote their local economy through value-added opportunities, new business development, and improved efficiency in established operations.

Environmental Resilience-Providing innovative research and extension programming to enhance and protect managed and natural ecosystems, ecosystem services, and human well-being. Exploring potential issues resulting from global climate change, and possible mitigation and adaptation strategies.

Global Engagement-Providing global solutions to challenges in agriculture, health, and sustainability that affect the future of an interconnected world.

Integrated Health Solutions-Advancing and improving the health of people, animals, and communities through research and extension programming into preventive, corrective, diagnostic, and predictive solutions to challenges presented by food safety, lifestyle, diseases, pests, and toxins.

Positive Future for Youth, Families, and Children-Providing a wide range of evidence-based programming to support healthy families, build positive youth skills, and strengthen intergenerational relationships within rural and urban communities.

Diverse teams of faculty from the College of Agricultural Sciences are addressing complex societal issues that transcend disciplines to impact people on scales ranging from local to global.

Our planned programs capture the systems approach that we have identified as a key element for generating impact, uniting our research efforts with our extension education capacity. Penn State provides an environment that encourages interdisciplinary work and values outreach to stakeholders. The University has built a framework of university-wide consortia and institutes (e.g., Life Sciences; Energy and Environment; Social Sciences--Children, Youth, and Families; Materials; Ethics; Sustainability), and the College of Agricultural Sciences plays an integral role in these organizations. This interdisciplinary philosophy has reinforced the natural tendency of our faculty and extension educators to work cooperatively to solve problems. Coupled with the joint research-extension appointments of over 200 of our college faculty, our work effectively unites fundamental knowledge with practical solutions delivered to stakeholders. The net result is a tangible benefit in economic prosperity and quality of life for Pennsylvania citizens and beyond.

This Year's Program Highlights. In addition to the projects highlighted in summaries for each Planned Program, we had other stand-out projects in all aspects of our research and extension programs. We mention here just a few.

Advanced Agricultural and Food Systems projects featured two first reports: first North American report of allium leafminer on onions and first report of black rot on arugula in California.

Teams of scientists are diversifying Christmas tree breeding stock for needle retention and conducting yearly trials of flower varieties for the commercial market.

Several projects address climate change, for example, studies of its effects on animal agriculture in Pennsylvania and on insects in the U.S., and an analysis of the uncertainty surrounding U.S. livestock methane emission estimates. Extension work includes programs on managing orchards with climate

change.

Other extension highlights include a virtual farm website to explore options in dairy farm sustainability.

The College's research and extension work contributes directly to the success and health of the agriculture sector in Pennsylvania. The College's Fruit Research and Extension Center in Biglerville, PA, celebrated its 100th year of industry collaboration and innovation in 2018. The Penn State Mushroom Short Course marked its 60th year of providing mushroom growers with researched-based information and expertise aimed at advancing the industry.

Illustrating the broad nature of the program on Biologically Based Materials and Products, we have a project seeking to determine whether Brazil nut meat and egg powders could be used as cost-effective alternatives to synthetic methionine in organic laying hen diets, an economic assessment of landowners' willingness to supply energy crops on marginal lands in the Northeast U.S., and an assessment of strategic entrepreneurship among pallet manufacturers who seek revenue-generating methods of managing wood waste versus those who pay to dispose of it.

In the Community Resilience and Capacity program, our Shale extension team continues to expand and excel. They offer a monthly webinar series and are developing Spanish language digital materials. They've created an online biosecurity course for natural gas contractors working on farms. They continue to be in high demand to educate foreign government officials about what has worked in Pennsylvania and what to look out for in natural gas development.

Other projects in this area include analysis of how flooding and recent changes to the federal flood insurance program are affecting rural Pennsylvania, changes in farming in the Marcellus shale region associated with unconventional natural gas drilling activity, and the economic impact of organic agriculture hotspots.

Climate change, migration, and regional economic impacts in the U.S. were the focus of a study in the Environmental Resilience program, as were the assessment of estrogens in vernal pools and an analysis of the potential to improve water quality in Chesapeake Bay using payments for ecosystem services. Other researchers in this area worked on the fight against invasive insects such as spotted lanternfly and Asian long-horned beetle, and continuing progress toward restoration of the American chestnut tree.

Some extension program highlights include an educational program centered around nontimber forest products (food, medicinals, etc.), and the Master Watershed program, in which more than 300 volunteers conduct water quality sampling, stream cleanups, freshwater mussel monitoring, public education about water quality issues, and much more. The Green Industry team developed a golf course nutrient management program and revised home lawn fertilizer recommendations, both of which will help improve Chesapeake Bay water quality.

Several studies in the Global Engagement planned program address climate change: an analysis of climate in the crop yield record of SubSaharan Africa, determination that agroforestry may help mitigate climate change, and an exploration of how a heterogenous climate affects migration in Indonesia.

A number of projects within Global Engagement address insect-borne diseases. Our researchers are examining the adoption of innovations to reduce malaria, risk factors for asymptomatic malaria in seasonal surveys along the China-Myanmar border among displaced persons, and urbanization as related to hantavirus epidemics in Chinese cities.

We're also involved in global work to build diversity and sustainability of agricultural crops. Some examples of this type of work include efforts to foster the craft chocolate market to increase cacao growers' incomes

by analyzing how plant cultivars, climate, soil, and processing methods influence flavor and aroma characteristics of cacao beans, and efforts to empower female farmers in Cambodia by teaching them to grow a diverse, nutritious, and affordable supply of food.

Several projects within the Integrated Health Solutions planned program examine how certain foods affect health, including a study of the impacts of dietary broccoli on the gut microbiome, and the finding that mushrooms may help reduce diabetes in mice.

Some researchers are examining the prevention of drug resistance in dairy calves. Other researchers are modeling Marek's disease transmission in chickens, or studying Johne's disease in cattle.

Still other teams are attempting to identify new antimicrobials from ants, and to test the repellency and toxicity of natural compounds against certain ticks.

We also have researchers studying the healthfulness of at-home food expenditures, and the local food environment and child obesity.

Integrated Health Solutions extension programs address drinking water quality, respirator fit for safe application of farm chemicals, food service/foodborne diseases, and compliance with Food Safety Modernization Act regulations, as well as farm animal health.

Some highlights of the Positive Futures for Youth, Families, and Children program are a quantification of the economic value of poor mental health days, a study showing that investing in public education increases upward mobility, and two projects related to the concentration of poverty, both rural and urban, since 2000.

Our faculty conducted a program that supports youth as social science researchers in their communities, and analyzed predictors of leadership skills in Pennsylvania youth.

This planned program contains strong and continuing extension offerings such as PROSPER, Better Kid Care, and the Strengthening Families Program.

We expect to have a draft of our next College Strategic Plan by fall 2020, when the final university-wide Penn State Strategic Plan for 2021-2026 should be completed.

Total Actual Amount of professional FTEs/SYs for this State

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	460.9	0.0	705.2	0.0
Actual	418.8	0.0	424.7	0.0

II. Merit Review Process

1. The Merit Review Process that was Employed for this year

- Internal University Panel
- External University Panel

- External Non-University Panel
- Combined External and Internal University Panel
- Combined External and Internal University External Non-University Panel
- Expert Peer Review

2. Brief Explanation

Internal university panels review AES projects. At least two qualified faculty internally review Hatch, McIntire-Stennis, Animal Health, and State projects at initiation for the following metrics: 1) Relevance to priorities and mission of the units; 2) Probability of practical benefits; 3) Probability of contribution to basic knowledge; 4) Personnel available and qualified to do proposed work; 5) Provision for cooperative efforts; 6) Adequacy of equipment and facilities available; 7) Probability that objectives will be reached in proposed duration; 8) Proposal complete and format conforms to AES guidelines; and 9) Overall scientific and technical quality.

In addition, external university panels are used for Multistate Research Project (MRP) activities. These projects are reviewed multiple times during the five-year duration. At initiation, multistate activities are evaluated for sound scientific approach, achievable goals/objectives, appropriate scope of activity to accomplish objectives, potential for significant outputs (products) and outcomes and/or impacts; and overall technical merit. Midterm evaluations rate progress reports and accomplishment of state objectives, linkages among project participants and with other projects/agencies, funding sought or obtained, and success or plans for information and technology transfer. Both extension and academic faculty are encouraged to participate to meet the jointly agreed objectives.

External non-university panels are used as new Penn State extension programmatic issues or AES projects are implemented. Stakeholder and/or program advisory groups provide ongoing review of programs to ensure a focus on priority needs as identified by external panels. Reviewers' comments provide mechanisms for improving our educational and research programs.

Combined internal and external university panels are assigned to each of the programmatic issues. These panels are representative of integrated, multidisciplinary State Program Team Units made up of field-based extension educators and faculty with split extension/research appointments. Program Team members broadly represent all parts of the Commonwealth, and faculty members are chosen to represent relevant research and extension perspectives. Extension Assistant Directors of Programs provide overall leadership to the State Program Teams, and extension administrators review programs. State administrators and academic unit leaders serve as liaisons to each unit. Each State Program Team developed a program plan, based on formal needs assessment processes, that guides extension programming and applied research efforts.

Combined internal and external university and external non-university panels were used to create advisory committees for each State Program Team. These panels assisted in identifying issues where expertise can be applied in program efforts. The work plans were developed and revised with input from the panel members.

III. Stakeholder Input

1. Actions taken to seek stakeholder input that encouraged their participation

- Use of media to announce public meetings and listening sessions
- Targeted invitation to traditional stakeholder groups
- Targeted invitation to non-traditional stakeholder groups
- Targeted invitation to traditional stakeholder individuals
- Targeted invitation to non-traditional stakeholder individuals
- Targeted invitation to selected individuals from general public
- Survey of traditional stakeholder groups
- Survey of traditional stakeholder individuals
- Survey of the general public
- Survey specifically with non-traditional groups
- Survey specifically with non-traditional individuals
- Survey of selected individuals from the general public
- Other (County Extension Boards)

Brief explanation.

College administration and faculty advisory groups confer regularly with key stakeholder groups. The Penn State Ag Council (http://agsci.psu.edu/business/agcouncil) provides us with direct contact to nearly 100 member organizations and groups representing the agricultural industry across Pennsylvania. Also, part of the Ag Council are organizations such as the Chesapeake Bay Foundation and the County Commissioners Association of PA.

In addition, college leadership meet regularly with individual stakeholder groups, such as the Pennsylvania Farm Bureau and PennAg Industries, and state and federal partners, including the Pennsylvania Departments of Environmental Protection and Conservation and Natural Resources, the US Department of Agriculture, and the US Environmental Protection Agency.

Targeted invitations to traditional and non-traditional stakeholder groups and/or individuals are extended to these stakeholders and members of the general public to identify industry representatives and/or individuals who would formulate program advisory committees (e.g., Green Industry Statewide Advisory Board, Center for Pollinator Research's Stakeholder Advisory Board, PROSPER program collaborators).

Surveys and/or focus group meetings of traditional and non-traditional stakeholder groups and/or individuals are used to collect more detailed information. For example, the Equine extension team surveyed stakeholders about their interests in various extension programs and their preferences for times, formats, and locations.

Each year, various programs within the College participate in outreach events, such as the Pennsylvania Farm Show, Ag Progress Days, and the Great Insect Fair. Informal discussions at these events bring valuable feedback.

Penn State Extension has implemented a new Program Development Process that all Extension Program Teams use to leverage our areas of excellence and educational expertise to focus on the most relevant and highest priority issues of our stakeholders and customers. This formal, facilitated

process uses market research and requires extensive stakeholder input.

The Penn State Extension offices in Philadelphia and Pittsburgh greatly expand the reach of our programs to traditionally under-served urban audiences.

No matter the method of engagement, we seek feedback on the quality and relevance of our programs, the quality of our presenters, suggestions of other resources stakeholders need, etc. We sometimes collect more detailed retrospective evaluations to gather information from participants who actually put into practice lessons learned through extension programs. Attempting to measure costs averted or profit increased can show powerful, tangible benefits of our programming. Some of our successes in these measures are highlighted in the projects featured in this annual report.

Faculty use research by stakeholder groups to inform their decisions about which research projects to pursue. For instance, an industry-wide survey by the PA Wine Marketing and Research Board identified varietal selection and best management practices as two top priorities. Our faculty are answering that call with research in these topics.

2(A). A brief statement of the process that was used by the recipient institution to identify individuals and groups stakeholders and to collect input from them

1. Method to identify individuals and groups

- Use Advisory Committees
- Use Internal Focus Groups
- Use External Focus Groups
- Open Listening Sessions
- Needs Assessments
- Use Surveys
- Other (External Consultants)

Brief explanation.

Advisory committees, such as program advisory committees at the county, district, and state extension unit level and the University Industry Advisory Committee, assisted our programs with identification and selection of stakeholder individuals and groups. Program advisory committee members were selected to represent program areas, emerging issues, geographic areas, and population diversity. These groups helped extension educators with program design and implementation, which may include identifying resources to support the programs, tailoring the content to specific audience needs, and marketing the programs to targeted audiences and communities.

External focus groups, such as the County Extension Boards, were representative of demographics of the county/district in which they serve, and where appropriate, Hispanics, African Americans, Asians, Anabaptists, or other minorities serve on the groups and provide input to extension programs. Our programs met the needs of traditional agricultural information consumers (e.g., farmers, rural residents), as well as homeowners; newer audiences such as urban farmers; and, increasingly, those historically underserved by extension. Our reorganization of Extension in 2017 was designed to increase both the diversity of our stakeholder groups and our stakeholders' benefits from our programs.

Penn State Ag Council meetings were publicly announced, and broad representation was continually reassessed to ensure the inclusion of new and traditionally underserved audiences.

External consultants (i.e., Fieldstone Innovations, etc.) were contracted to assist in identifying industry stakeholders that can provide leveraging dollars and research opportunities for faculty and help establish long-term working relationships.

Maintaining contact with alumni is an important strategy throughout the College. This helps meet our students' needs for career networking, builds direct links to our stakeholder groups and industries, and increases the likelihood of leveraging funds in the future. Alumni and friends' banquets and football tailgates were common throughout the College, and enjoyed continuing high attendance.

Our faculty served on dozens of state and federal government and professional association boards and groups. Their selection and election to these roles reflects their stature in their fields. They will continue this service.

Our Agricultural Experiment Station Director's service as chair of the APLU ESCOP last year, and accompanying broad engagement with NIFA and stakeholder groups, brought insights and guidance unique within the system.

2(B). A brief statement of the process that was used by the recipient institution to identify individuals and groups who are stakeholders and to collect input from them

1. Methods for collecting Stakeholder Input

- Meeting with traditional Stakeholder groups
- Survey of traditional Stakeholder groups
- Meeting with traditional Stakeholder individuals
- Survey of traditional Stakeholder individuals
- Survey of the general public
- Meeting specifically with non-traditional groups
- Survey specifically with non-traditional groups
- Meeting specifically with non-traditional individuals
- Survey specifically with non-traditional individuals

Brief explanation.

To collect stakeholder input, educators or faculty held regularly scheduled meetings, such as advisory groups and Penn State Ag Council. Research commercialization was featured during the Ag Council research tour on campus. The Food Safety Modernization Act extension team, through funds from a USDA-NIFA grant, is working with an Amish produce growers' group on the development of culturally relevant learning tools and on co-teaching sessions to help this underserved group comply with the federal produce safety regulation.

Many programs regularly use surveys of traditional stakeholder groups to gauge how current programs meet clients' needs. For example, the Equine extension team surveyed stakeholders via email and Facebook to gather information about topics of interest and preferred times, locations, and formats for learning.

Requests for information from extension staff provided additional measures of client needs. If similar information is requested repeatedly, we try to develop a resource to meet that need.

Extension teams very often receive unsolicited emails, calls, and in-person testimonials about the positive impacts extension trainings or information have had on clients' operations. For example, the

Poultry extension team says, "Stakeholders agree. The areas of research the team is pursing are addressing critical production issues. This feedback is important for the continued support of the poultry team, the Poultry Research Check-Off, and our efforts to improve poultry production."

More extension programs are collecting long-term follow-up data, surveying participants three months or more after an educational event to gather information about actual changes that have been made, and the associated costs and added values. More extension programs are also estimating economic impacts.

Many programs held regular field tours (e.g., pasture walks) and site tours, which allowed them to see conditions on the ground and hear from stakeholders directly. The dean led an industry tour to the Pittsburgh area focusing on the green industry and entrepreneurship and innovation.

Most departments and extension program teams held at least annual meetings with stakeholders to share updates and gather feedback.

There is a continuing demand for classes, including those necessary for required certifications, such as those for retail food service managers, despite the fact that other organizations may offer them in shorter, less expensive formats.

3. A statement of how the input will be considered

- In the Budget Process
- To Identify Emerging Issues
- Redirect Extension Programs
- Redirect Research Programs
- In the Staff Hiring Process
- In the Action Plans
- To Set Priorities
- Other (how and where programs are offered)

Brief explanation.

Budget Process: Availability of extramural funding influenced resource allocations.

To Identify Emerging Issues: Stakeholder feedback helped to identify emerging issues that would benefit from extension programming and/or research when multiple stakeholders indicated the same need. For example, our entomology programming regularly adjusts to provide education about the latest invasive insects, most recently spotted lanternfly.

Redirect Extension Programs: Information collected from stakeholders was used to adjust focus areas for Extension programming. For example, programming to meet the requirements for the Food Safety Manufacturing Act has grown over the past couple of years.

Redirect Research Programs: Information collected from stakeholder groups, such as industry associations, directly influenced applied research activity through local decisions about priorities. For example, responses to the industry-wide PA Wine Marketing and Research Board survey have influenced research directions in the Grape Profitability and Sustainability extension program.

In the Staff Hiring Process: Information collected from stakeholders influenced hiring decisions for faculty and extension educators to address unmet needs. Stakeholder feedback also indicated

where volunteers and donors would be interested in assisting with programs and initiatives. The reorganization of Extension in 2017 demonstrates our commitment to maximizing our programming's benefit to our clients. Fairly extensive reorganization of staff was needed to implement this plan. To meet emerging needs, we also hired new faculty, for example, in harvesting mechanization, and new staff, such as a research technologist to act as a liaison among PSU researchers and residents and mushroom growers in the Chester County region.

In the Action Plans: Our mission is to serve our stakeholders, so we analyzed their feedback and adjusted our action plans to meet their needs. For example, the Forestry extension team is developing new programs in fire ecology, fire management, and prescribed burning in response to unmet needs in the Northeast and Mid-Atlantic.

To Set Priorities: Our stakeholders' priorities must be our priorities, and we adjusted our programs as needed. For example, the Tree Fruit extension team has an expanding focus on orchard mechanization to ease continuing labor shortage issues.

Other - How and Where programs are offered: Stakeholder input directly affects how we offer our extension programs. Feedback indicated that additional methods of program delivery were needed as demands for resources and/or time increased. Our new and expanding online education programs dramatically increase the reach and distribution of extension products and services, making them available when, how, and where customers want them. Digital products complement current face-to-face programming and allow educators to utilize their in-the-field time more strategically by putting routine educational materials online.

Brief Explanation of what you learned from your Stakeholders

Stakeholder input directly affects how we offer our extension programs. Feedback indicated that participants need adaptations in programs because many have little money or time available for travel. As a result, educational opportunities are being offered via other methods, such as home-study courses, pasture walks, podcasts, and online webinars, via synchronous and asynchronous means, and the number of interactions in a traditional classroom setting is declining. In addition, stakeholder input helps determine the locations, times, and frequencies that extension programs are offered.

Globalization of research efforts, outcomes, and extension is increasingly important. As more and more people travel and the Internet and mobile phones break down barriers to information, scientists are realizing that a crop or technique that works in Pennsylvania might be adaptable to places in Africa, for instance. With travel comes increased threat of epidemics and transfer of diseases from farm animals to people.

Research commercialization, engagement with industry, and economic development are important to our stakeholders. As grant funding becomes tighter, there is greater pressure to raise funds by commercializing research innovations. Most of our programs, including the Biologically Based Materials and Products researchers, the Shale Education team, the Food Science team, and the Integrated Crop Production team, are engaged in some degree of effort in this area.

The Food Safety Modernization Act and Good Agricultural Practices regulations continue to challenge our stakeholders and drive new and continuing programs. In addition to participation by food industry partners, these training workshops have been attended by regulators, including FDA inspectors and members of the USDA Foreign Agricultural Service. They have found our training programs to provide a high level of technical accuracy and sufficient depth to enhance inspector knowledge.

We are also seeing the tremendous benefits of interdisciplinary teams in solving problems. A group of experts who all bring to the problem a part of the solution can often move beyond the sum of their knowledge. For example, the Forestry, Grape, Green Industry, Master Gardeners, and Tree Fruit extension teams are collaborating on the all-hands-on-deck effort to fight the spotted lanternfly invasion. The grape, tree fruit, hardwood, and nursery industries collectively are worth nearly $18 billion to the state's economy.

Our Strategic Networks for Innovations Program (SNIP) provides internal funding to interdisciplinary team development.

IV. Expenditure Summary

1. Total Actual Formula dollars Allocated (prepopulated from C-REEMS)			
Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
{No Data Entered}	{No Data Entered}	{No Data Entered}	{No Data Entered}

2. Totaled Actual dollars from Planned Programs Inputs				
	Extension		Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	7519348	0	6909555	0
Actual Matching	25764750	0	31057346	0
Actual All Other	23439786	0	36997442	0
Total Actual Expended	56723884	0	74964343	0

3. Amount of Above Actual Formula Dollars Expended which comes from Carryover funds from previous				
Carryover	5630059	0	3311442	0

V. Planned Program Table of Content

V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

Advanced Agricultural and Food Systems

☑ 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	8%		7%	
111	Conservation and Efficient Use of Water	9%		7%	
132	Weather and Climate	8%		7%	
135	Aquatic and Terrestrial Wildlife	0%		5%	
136	Conservation of Biological Diversity	0%		5%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants	8%		7%	
211	Insects, Mites, and Other Arthropods Affecting Plants	8%		7%	
215	Biological Control of Pests Affecting Plants	8%		7%	
216	Integrated Pest Management Systems	8%		7%	
302	Nutrient Utilization in Animals	8%		7%	
307	Animal Management Systems	9%		7%	
308	Improved Animal Products (Before Harvest)	8%		7%	
311	Animal Diseases	0%		6%	
601	Economics of Agricultural Production and Farm Management	9%		7%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources	9%		7%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	24.7	0.0	20.5	0.0
Actual Paid	29.4	0.0	17.1	0.0

Actual Volunteer	6.9	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**
3708374	0	2489979	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
12183133	0	10959674	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
5579372	0	9692826	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

All kinds of crops research happens at Penn State under the Advanced Agricultural and Food Sciences planned program. Some samples: a project that found the potential for increased profits from manure injection versus manure broadcast on corn silage; assessment of organic management and diversified grain cropping systems as ways to reduce energy use and greenhouse gas emissions in agriculture; and development of new malting barley lines with traits brewers seek.

Research in this planned program runs the gamut across the incredibly diverse field of agriculture--from a look at the global organization of root functional traits to consumer preferences for sustainable wine attributes; from assessment of the effects of storage temperature on aroma of coffee beans to analysis of apple grower pollination practices and perceptions of alternative pollinators in New York and Pennsylvania.

Dairy researchers evaluated, among other things, the effects of organic trace minerals on growth, reproduction, and fat in dairy heifers, and developed a vision for dairy farms in 2067.

The Dairy extension team is running a multi-year crop-to-cow-to-cash project to evaluate the details related to corn silage hybrid selection, planting, harvesting, and feeding, and the effects on farm financials. Based on the results to date, producers have changed their strategies on hybrid selection, adjusted kernel processing of their corn silage, and modified feed management practices to meet the formulated ration nutrient specifications. This project will help evaluate how management decisions influenced farm profitability over time.

The Tree Fruit Profitability and Sustainability extension team surveyed winter tree fruit school participants, who estimated the economic impact of what they'd learned about disease management, insects/mites, and crop load. Growers estimated the economic impact to be $126, $112, and $142 per acre for improved management of diseases, insects/mites, and crop load, respectively.

The Green Industry extension team's efforts against invasive spotted lanternfly included training volunteers to use sticky bands on their ailanthus trees. Sixty volunteers reported killing a total of nearly 600,000 spotted lanternflies on these bands.

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
- Nonprofit associations/Organizations

3. How was eXtension used?

At least some members of most extension units answered Ask an Expert questions and directed clients to appropriate eXtension publications as additional resources when discussing issues and concerns. Team members also used eXtension as a source of information for acquiring personal knowledge.

Team members provided webinars and e-newsletters to the eXtension community, which is accessed by participants from all over the world.

Members of the Livestock and Poultry Environmental Learning Center collaborated and exchanged information on nutrient management and mortality management. Members of the EDEN CoP exchanged resources on emergency management and response resource plans.

Penn State 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 Extension supports the professional development offered through eXtension.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	75945	1104767	15675	3714

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	6

Patents listed
Serial No. 62/594,145; Filed 12/6/1017; Title: Male Fertility-Specific Genetic Diagnostic Assay for Bull Fertility Evaluation and Selection

Serial No. 62/727,732; Filed 9/6/2018; Title: Apparatus and Method for Rejuvenation and Recovery of Filtration Media

Serial No. 15/830, 513; Filed 12/4/2017; Title: 3D Laser Ablation Tomography and Spectrographic

Serial No. PCT/US2018/026913; Filed 4/10/2018; Title: Compositions and Methods Compromising Viral Reverse Transcriptase

Serial No. 62/584, 442; Filed 11/10/2017; Title: Targeted Modification of Maize Root Angle to Enhance Abiotic Stress Tolerance and Carbon Sequestration

Serial No. 62/673, 475; Filed 5/18/2018; Title: Broad Spectrum Pesticide and Fungicide

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	52	207	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of participants in extension education classes and workshops.
  Not reporting on this Output for this Annual Report

Output #2

Output Measure

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

Year	Actual
2018	4

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	New crop varieties or lines.
2	Improved efficiency of operation for livestock producers.
3	Average cost savings from implementation of program suggestions.
4	Greater understanding of the biology of an invasive pest and/or new strategy for combating.
5	Cost savings from more efficient use of pesticide and/or herbicide.
6	Enhanced knowledge to address the pollinator crisis.
7	Innovation in farm machinery to increase efficiency and reduce labor costs.
8	Improved understanding of agricultural change expected with climate change.
9	Improved efficiency of operation for livestock production: Increase (in $) in total annual earnings to PA dairy farms raising Holstein calves for beef
10	Evaluation of feeding preferences for heritage turkey production, a profitable and growing market
11	Greater understanding of invasive pests or new strategies to combat them: Methods of controlling brown marmorated stink bugs
12	Knowledge to address the pollinator crisis: identification of 27 never-before-seen viruses affecting bees worldwide
13	Improved understanding of agricultural change expected with climate change

Outcome #1

1. **Outcome Measures**

New crop varieties or lines.

Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

Improved efficiency of operation for livestock producers.

Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

Average cost savings from implementation of program suggestions.

Not Reporting on this Outcome Measure

Outcome #4

1. **Outcome Measures**

Greater understanding of the biology of an invasive pest and/or new strategy for combating.

Not Reporting on this Outcome Measure

Outcome #5

1. **Outcome Measures**

Cost savings from more efficient use of pesticide and/or herbicide.

Not Reporting on this Outcome Measure

Outcome #6

1. **Outcome Measures**

Enhanced knowledge to address the pollinator crisis.

Not Reporting on this Outcome Measure

Outcome #7

1. **Outcome Measures**

Innovation in farm machinery to increase efficiency and reduce labor costs.

Not Reporting on this Outcome Measure

Outcome #8

1. **Outcome Measures**

Improved understanding of agricultural change expected with climate change.

Not Reporting on this Outcome Measure

Outcome #9

1. **Outcome Measures**

Improved efficiency of operation for livestock production: Increase (in $) in total annual earnings to PA dairy farms raising Holstein calves for beef

2. **Associated Institution Types**

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	18000000

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
PA is ranked sixth in total milk production (10.8 billion pounds of milk per year) nationally. But many PA dairies are folding, and co-ops are closing. Several factors are cutting into dairy profits: the demand for fluid milk is way down, supply is up, and milk prices have plummeted; one of the nation's leading beverage companies is terminating milk-procurement contracts in PA; and a well-recognized multinational retailer is building a huge milk processing and distribution plant in the Midwest.

What has been done
With leveraged funding from the PA Beef Producers Working Group, the Calf-fed Holsteins Reared for Beef Demonstration Project was begun to show dairy farmers how to boost revenue from their operations. Now, with the financial crisis gripping Pennsylvania's dairy industry, the approach is an option for many dairy producers in the state to keep their farms alive.

Results
Dairy calves raised for beef must be managed for beef production. Holstein calves receive steroidal implants to increase growth, as most beef cattle do. Another aspect of proper management includes providing adequate nutrition. Calf-fed Holsteins should be raised on a high grain diet in confinement from birth to slaughter. Nutrition and implants ensure that calf-fed Holsteins will produce high-quality steaks and desired cuts of meat.

Communications with JBS USA, an international beef packing company, indicated that over the past three years their Pennsylvania plant has increased the number of calf-fed Holsteins processed by about 200%. In addition, producers applying nutrition and implant techniques taught by extension increased the average value of their cattle from $975 to $1330 per head. This average increase of $355 per head represents about $18,000,000 in gross revenue return for Holsteins reared for beef in PA.

4. Associated Knowledge Areas

KA Code	Knowledge Area
302	Nutrient Utilization in Animals
307	Animal Management Systems
308	Improved Animal Products (Before Harvest)
601	Economics of Agricultural Production and Farm Management

Outcome #10

1. Outcome Measures

Evaluation of feeding preferences for heritage turkey production, a profitable and growing market

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Some producers of heritage turkeys report increasing their flocks by 68-85% annually, but still being unable to keep up with demand. To help meet increasing consumer demand for heritage-breed turkeys for holiday and other meals, a team of Penn State researchers is studying new methods producers can use to raise the birds. Few studies have evaluated the feed intake and performance of heritage-breed turkeys.

What has been done
A feeding trial incorporated 15% natural feedstuffs into heritage turkeys' diet. To determine their conversion of feed into meat, birds were weighed weekly and their feed intake measured. At processing, the birds that consumed natural feedstuffs weighed essentially the same as turkeys in the control group that ate only commercial poultry feed. The team noted the kinds of feedstuffs the birds preferred. The growth of heritage turkeys may depend on the palatability of the natural feedstuffs.

Results
Heritage turkeys sell for about four times the cost of the broad-breasted white turkeys commonly available. The average store-bought turkey costs about $1 per pound, while heritage turkeys can run between $4 and $6 per pound. Because the market for them is growing and consumers are willing to pay so much more for heritage turkeys, there is considerable interest in producing more.

The next phase of the research will involve raising heritage birds in a silvopasture system where they will forage for natural feedstuffs outdoors, to supplement commercial feed. Silvopasture integrates trees and shrubs with forage for poultry and livestock production. This system can provide forage, berries, nuts, and insects for the turkeys to eat throughout the rearing period. The approach might be ideal for raising heritage turkeys in Pennsylvania and the Northeast, where smaller farms abound.

4. Associated Knowledge Areas

KA Code	Knowledge Area
302	Nutrient Utilization in Animals
307	Animal Management Systems

Outcome #11

1. Outcome Measures

Greater understanding of invasive pests or new strategies to combat them: Methods of controlling brown marmorated stink bugs

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
In the Mid-Atlantic, brown marmorated stink bugs (BMSB) threaten fruits, vegetables, and ornamentals. In 2010, they caused losses of about $35 million just to apple growers. Synthetic pesticides are the most reliable and economical tool to control BMSB, but overuse is hurting beneficial insects and causing outbreaks of secondary pests. Researchers have sought to develop biological control methods to reduce BMSB reproduction. Biological control in its native Asia is very effective.

What has been done
Recent research activities focus on the development and validation of effective BMSB monitoring and management strategies. The most effective beneficial insect for BMSB biological control, the native samurai wasp, develops inside stink bug eggs, and quite reliably keeps BMSB populations in check. The samurai wasp has been found in 10 states, including PA.

?Ghost traps? also show promise in reducing reliance on pesticides against BMSB.

Results
Entomologists may decide to culture and release samurai wasps where populations of BMSBs are high and menacing crops. With the parasitic wasp already naturally occurring in PA agroecosystems, efforts will attempt to enhance its survival and distribution within BMSB-affected areas. Findings across the state are good indicators for the future statewide establishment of this beneficial insect.

A Penn State-led team also found that insecticide-treated nets baited with a BMSB aggregation pheromone and draped over a shepherd's hook represent a potent new tool for BMSB monitoring

and potentially management. The "ghost traps" draw and kill hundreds of BMSB adults and nymphs. This new tactic allows some control of BMSB without pesticide application to crops. By reducing the number and volume of insecticide applications, it also indirectly supports the establishment of samurai wasps in and around orchards. The team is continuing to study and refine suggestions for use.

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources

Outcome #12

1. Outcome Measures

Knowledge to address the pollinator crisis: identification of 27 never-before-seen viruses affecting bees worldwide

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Populations of bees around the world are declining, and viruses are known to contribute to these declines. Despite the importance of bees as pollinators of flowering plants in agricultural and natural landscapes and the importance of viruses to bee health, our understanding of bee viruses is surprisingly limited.

What has been done
An international team of researchers collected samples of DNA and RNA from 12 bee species in nine countries around the world. Next, they developed a novel high-throughput sequencing technique that efficiently detected in a single experiment both previously identified and 27 never-before-seen viruses belonging to at least six new families. The new method allowed the team to sequence all the viruses present in a sample without having any prior knowledge about what

might be there.

Results
The findings could help scientists design strategies to prevent the spread of viral pathogens among these important pollinators.

The results also highlight the importance of monitoring bee populations brought into the United States because of the potential for these species to transmit viruses to local pollinator populations. The new viruses identified can now be used in screening processes to monitor bee health around the world.

Because the cost of high-throughput sequencing continues to decrease, the team's approach provides an inexpensive and efficient technique for other researchers to identify additional unknown viruses in bee populations around the world.

The team hopes to do further research to determine whether the viruses are actively infecting the bees and if the bees may be passing viruses to crop plants.

4. Associated Knowledge Areas

KA Code	Knowledge Area
135	Aquatic and Terrestrial Wildlife
136	Conservation of Biological Diversity
211	Insects, Mites, and Other Arthropods Affecting Plants
311	Animal Diseases

Outcome #13

1. Outcome Measures

Improved understanding of agricultural change expected with climate change

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Climate projections indicate that the Northeast is the fastest warming region in the United States, and that could have implications for corn crops and dairy farms in the region by 2050.

What has been done
Using localized projected climate data from nine global climate models, researchers judged future corn-growing conditions at Syracuse, New York; State College, Pennsylvania; and Landisville, Pennsylvania. They calculated the number and timing of expected extreme heat days and crop water-deficit periods.

Results
Rising temperatures are not likely to cause serious reductions in corn crops in the northern and central parts of the Northeast, but they threaten corn yields in the southern reaches of the region. Corn in the Northeast near the end of the 21st century will experience fewer spring and fall freezes and a faster rate of growing-degree-day accumulation with a reduction in time required to reach maturity, providing more opportunity for double cropping. Farmers in places such as Lancaster County, Pennsylvania, an area with many dairies heavily reliant on corn for feed, will likely have to change their corn-growing strategies to address extreme temperature stress during corn's key reproductive stages. Water deficits are also expected to be greatest during corn's reproductive stages. To adapt, farmers may have to plant earlier, adopt short-season hybrids, and even use irrigation to maintain corn yields adequate to sustain dairy farms.

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

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.)
- Other (Extramural Funding)

Brief Explanation

Natural disasters
Weather conditions can drive clients' requests for programs and advice.

Weather conditions can necessitate changes in field research plans and workshops.

To address significant emerging issues with invasive and emerging pests such as the allium leaf miner, phorid fly, and spotted lanternfly, the Vegetable team had to reallocate both time and money resources.

Economy
The economic status of the PA dairy industry is forcing farmers to think long-term and diversify their enterprises.

The dairy industry was affected in the Great Recession, and we continue to see farmers and the industry in economic hardship. The price of milk has remained low for four years and is projected to remain below average. This causes economic hardship for producers.

Competing public priorities
Public perception of poultry production practices and cage-free legislation in California is bringing in a new crop of phone calls and emails to discuss and share information.

Government Regulations
The Food Safety Modernization Act (FSMA) and resulting regulations established the need to provide approved training via the Produce Safety Alliance (PSA). This new need has resulted in Vegetable team members becoming trained to conduct PSA training for producers and to participate in On-Farm Readiness Reviews (OFRR) throughout the state. This important program has reduced educator time available to work on other Vegetable team priorities.

Competing Programmatic Challenges
The increased paperwork required to conduct youth programs continues to make getting volunteers to help with 4-H youth poultry programming difficult.

Addressing the latest invasive species crises can take time and resources away from more established programs.

Funding for travel for delivery of programming has proven to be challenging.

Competing programs create time restrictions on development and proper coverage across a wide area.

Population changes
Hispanic labor is a huge and growing part of the labor force for dairy farms, creating a need for programs and publications to be delivered in Spanish.

Funding
Some of our programs are affected by 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 strongest evaluation of our programs comes from gathering pre- and post-training responses and the use of retrospective evaluation to assess whether participants actually

put into practice lessons learned through extension programs. More statewide extension programs are performing these kinds of meaningful evaluations, so our programs continue to grow stronger and our results continue to become more quantifiable and impactful. We are also finding greater willingness to estimate potential earnings or cost savings as a result of research outcomes.

A customer relationship management tool was implemented in September 2017. That will lead to more consistent implementation of post-event evaluations, which should allow for assessment of change in practice and possibly estimates of economic impacts. These post-event assessments will be used more broadly as time passes.

Key Items of Evaluation

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

V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

Biologically Based Materials and Products

☑ 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
212	Diseases and Nematodes Affecting Plants	25%		25%	
302	Nutrient Utilization in Animals	25%		25%	
511	New and Improved Non-Food Products and Processes	25%		25%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources	25%		25%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	11.9	0.0	1.9	0.0
Actual Paid	3.8	0.0	3.1	0.0
Actual Volunteer	3.4	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**
434127	0	458196	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1728749	0	1487742	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
888469	0	988672	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Some research highlights in the biologically based materials and products planned program include a patent application for a broad-spectrum pesticide and fungicide from plant natural compounds, and the search for a cost-effective alternative to synthetic methionine in organic laying hen diets.

Additional bioenergy research involves assessment of landowners' willingness to supply energy crops on marginal lands in the northeastern United States, and analysis of the entrepreneurial success of pallet manufacturers who sell wood waste rather than pay to discard it. A team assessed whether torrefying biomass boosts its capacity to absorb contaminants.

Continuing biobased products research projects involve optimizing a polysaccharide-based foam for wound care and tissue engineering, development of a new biomaterial that could replace plastic laminates and eliminate millions of tons of petroleum-based plastics each year, and refinement of the manufacturing process for a yellow-red natural food colorant from waste avocado pits.

Extension work in biologically based materials and products includes organizing and hosting on-site field days, demonstration site tours, individual site visits, and other on-site educational opportunities, as well as webinars, newsletters, and online outreach programs about bioenergy options. Extension staff provided assistance with renewable energy project financing, design, and logistics.

2. Brief description of the target audience

- Agricultural Producers/Farmers/Landowners
- Agriculture Services/Businesses
- Business/Industry
- Community Groups
- General Public
- Government Personnel
- Local, Regional, State, and Federal Agencies
- Nonprofit Associations/Organizations

3. How was eXtension used?

The Bioenergy team participated in the Sustainable Ag Energy Community of Practice, using materials on that team's site as reference material.

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.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	14627	35031	1953	261

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	2

Patents listed

Serial No. 15/572, 129; Filed 11/6/2017; Title: Multi-Surfactant Systems

Serial No. 15/854, 121; Filed 12/26/2017; Title: Radio Frequency Treatment to Phytosanitize Wood Packaging Materials used in International Shipping

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	6	51	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of participants in extension education classes and workshops.
  Not reporting on this Output for this Annual Report

Output #2

Output Measure

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

Year	Actual
2018	0

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Increased knowledge about a biologically based product or chemical or a novel biologically based product or chemical.
2	New or improved use for agricultural waste product.
3	Increased knowledge about biologically based materials and products: Patent application filed for broad-spectrum pesticide and fungicide from plant natural compounds
4	Increased knowledge about biologically based materials and products: Cost-effective alternative to synthetic methionine in organic laying hen diets

Outcome #1

1. **Outcome Measures**

Increased knowledge about a biologically based product or chemical or a novel biologically based product or chemical.

Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

New or improved use for agricultural waste product.

Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

Increased knowledge about biologically based materials and products: Patent application filed for broad-spectrum pesticide and fungicide from plant natural compounds

2. **Associated Institution Types**

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Modern agriculture typically tackles the myriad pests and pathogens that attack crop plants with synthetic chemicals, many of which are unsafe to humans and the environment. Pathogens can develop resistance to these chemicals. Consumers are concerned about residual toxicity of traditional pesticides and fungicides, so safe crop protection strategies are needed for sustainable production of economically important crops. New biobased pest control mechanisms are being explored.

What has been done
A Penn State research team has found that a group of flavonoid compounds produced in sorghum acts as natural pesticides and fungicides. The researchers have developed near-isogenic lines of sorghum and maize and used these to discover the role of flavonoid phytoalexins in host plant defense. This project has developed vast genetic resources while focusing on two anthracnose fungal pathogens, as well as insect pests. They filed a provisional patent application on the compounds? mode of action.

Results
This project demonstrated the role of sorghum flavonoids in anthracnose resistance using sorghum near-isogenic lines that differ in their ability to produce these flavonoids. The group made a striking discovery that in addition to fungal resistance these flavonoids also confer resistance against certain species of aphids. Through the understanding of plant genetics, this project is moving toward breeding sorghum and maize crops that can resist several different pests and pathogens. Plant-based biopesticides are considered nontoxic to humans but toxic to pests and pathogens, are environment-friendly, and may reduce the use of chemical pesticides.

4. Associated Knowledge Areas

KA Code	Knowledge Area
212	Diseases and Nematodes Affecting Plants
511	New and Improved Non-Food Products and Processes
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources

Outcome #4

1. Outcome Measures

Increased knowledge about biologically based materials and products: Cost-effective alternative to synthetic methionine in organic laying hen diets

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

USDA National Organic Program rulings in 2011 and 2012 limited the amount of synthetic methionine (Met) that can be added to organic poultry feed. All other synthetic amino acids are not allowed in the feed. Met is important for poultry growth and egg size.

What has been done
With leveraged funding from the PA Poultry Industry Egg Research Check-off Program, a study investigated Brazil nut protein powder, spray-dried egg white, and spray-dried egg blend as alternatives to synthetic Met in feed for organic laying hens. Spray-dried egg comes from eggs diverted from human consumption because of cracks and other imperfections. Measures included egg production and quality, body weight, feed intake, and manure nutrients and ammonia.

Results
Egg weight and production did not differ between hens fed a commercial control diet and the treatment diets. Both egg-based diets increased ammonia release from manure relative to the control diet. The spray-dried egg blend diet was most economical on both per dozen eggs ($0.73) and per kilogram of egg ($0.99) bases versus the organic diet ($1.44 and $1.93, respectively), suggesting that it could cost-effectively replace synthetic Met in organic laying hen diets without negatively affecting egg production. If an all-vegetarian diet is necessary, the Brazil nut protein powder is a viable option.

4. Associated Knowledge Areas

KA Code	Knowledge Area
302	Nutrient Utilization in Animals
511	New and Improved Non-Food Products and Processes
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Public Policy changes
- Government Regulations
- Other (Extramural Funding)

Brief Explanation

Economy
Continued low prices for fossil fuels have dampened enthusiasm for renewable energy, although improvements to the economy have also spurred interest in sustainable practices.

Public Policy Changes
Ongoing changes to rules (both real and perceived) at the federal level make long-term investment in energy a challenge, although emergence of the renewable natural gas credit market represents a great opportunity at present. Inconsistent or fluctuating policy decisions create uncertainty and risk in new and developing markets.

Government Regulations

Land use regulations, access limitations to the electrical distribution system, and air- and water-quality regulations all affect renewable energy feasibility.

Funding

Renewable and Alternative Energy team extension activities are guided largely by grant opportunities such as the State Wood Energy team grant and the Wood Innovations Grant biochar project. The end of the USDA AFRI NEWBio project has meant the loss of an extension associate from the energy team, which has hampered our ability to effectively deliver programming.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The strongest evaluation of our programs comes from gathering pre- and post-training responses and the use of retrospective evaluation to assess whether participants actually put into practice lessons learned through extension programs. More statewide extension programs are performing these kinds of meaningful evaluations, so our programs continue to grow stronger and our results continue to become more quantifiable and impactful. We are also finding greater willingness to estimate potential earnings or cost savings as a result of research outcomes.

A customer relationship management tool was implemented in September 2017. That will lead to more consistent implementation of post-event evaluations, which should allow for assessment of change in practice and possibly estimates of economic impacts. These post-event assessments will be used more broadly as time passes.

Key Items of Evaluation

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

V(A). Planned Program (Summary)

Program # 3

1. Name of the Planned Program

Community Resilience and Capacity

☑ 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
602	Business Management, Finance, and Taxation	10%		15%	
603	Market Economics	10%		10%	
608	Community Resource Planning and Development	10%		10%	
610	Domestic Policy Analysis	10%		10%	
703	Nutrition Education and Behavior	15%		10%	
723	Hazards to Human Health and Safety	10%		15%	
805	Community Institutions and Social Services	10%		10%	
902	Administration of Projects and Programs	10%		10%	
903	Communication, Education, and Information Delivery	15%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	2.9	0.0	3.6	0.0
Actual Paid	3.4	0.0	3.3	0.0
Actual Volunteer	19.0	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**
324412	0	570560	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1241070	0	1693632	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
1237598	0	975285	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

The Shale Energy extension team created and offered an online biosecurity course for shale gas workers on farms, offered monthly webinars, and created digital educational materials in Spanish for use with representatives of the Argentinian government and other Spanish-speaking countries. They also met with representatives of the governments of Brazil, Colombia, South Africa, the UK, and Australia about shale energy development in those countries. They participated in Pennsylvania Energy Horizons to develop a vision for the state's energy future in 2040.

The Shale Energy team submitted a research proposal to examine the opportunities for liquefied natural gas utilization in PA and the contiguous region. A separate research team studied how development of the Marcellus shale gas play has affected hotel supply and demand in the region.

The Ag Entrepreneurship/Economic and Community Development extension team supported and grew the hard cider extension program, which focuses on business development and marketing skills for this product to train businesses owners in sustainable economic planning and enable informed decision making for the health of their business. The team also organized and promoted the Lehigh Valley Open Gate Farm Tours to educating the public about local agriculture/agricultural literacy, while supporting the local agricultural economy.

2. Brief description of the target audience

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

- USDA
- 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.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	25052	157041	12918	300

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	1	70	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of participants in extension education classes and workshops.
  Not reporting on this Output for this Annual Report

Output #2

Output Measure

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

Year	Actual
2018	0

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Average cost savings from implementation of program suggestions.
2	Number of new and beginning farmers assisted.
3	Number of farms helped to implement added-value opportunities.
4	Average cost savings (in $) from implementing program suggestions: 1-year benefit to Pennsylvania if the Dining with Diabetes program were extended to half of the 1.3 million people living with diabetes in Pennsylvania and if they had similar improvements in diabetes-related biomarkers and lifestyle behaviors as past participants, assuming a conservative 15% decrease in direct medical costs
5	Finding that hotel demand and supply data from U.S. oil and gas shale plays shows a clear pattern of boom and bust related to drilling activity
6	Finding that a higher number of natural disasters experienced historically in a county is correlated with an increase in opioid overdoses

Outcome #1

1. **Outcome Measures**

Average cost savings from implementation of program suggestions.

Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

Number of new and beginning farmers assisted.

Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

Number of farms helped to implement added-value opportunities.

Not Reporting on this Outcome Measure

Outcome #4

1. **Outcome Measures**

Average cost savings (in $) from implementing program suggestions: 1-year benefit to Pennsylvania if the Dining with Diabetes program were extended to half of the 1.3 million people living with diabetes in Pennsylvania and if they had similar improvements in diabetes-related biomarkers and lifestyle behaviors as past participants, assuming a conservative 15% decrease in direct medical costs

2. **Associated Institution Types**

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual

2018 195000000

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
About 1.3 million Pennsylvanians (12.1%) have diabetes, and about 25% of them are not aware of it. Diabetes costs about $13.4 billion in PA each year, and people with diabetes have medical expenses 2.3 times higher than those who do not. According to the CDC, only 50-60% of adults with diabetes have attended a diabetes self-management class, over 35% are physically inactive, more than 85% are overweight or obese, greater than 65% have high blood pressure, and over 55% have elevated cholesterol.

What has been done
To help address this issue, 53 Dining with Diabetes (DWD) community-based programs were offered in 32 rural, suburban, and urban counties. Extension educators taught a series of four classes, each 2.5 hours, plus a follow-up class, and reached 693 participants. Additionally, 36 individuals participated in the online Dining with Diabetes course.

Results
Over the 3-month span of the program, 64% of participants experienced an improvement in their HbA1C score, which indicates lower likelihood of diabetes-related complications, and 66% of participants experienced an improvement in their blood pressure reading. With improvements in biomarkers, health care costs are reduced. Diabetes community education programs reduce the risk of diabetes by over 50%.

For every $1 spent on the program, the benefit to society in the form of reduced medical costs over five years is $3.35, and over 10 years is $6.24. If the DWD program were extended to just 50% of the 1.3 million people with diabetes in Pennsylvania and if they experienced a similar reduction in diabetes, the 1-year benefit to the state would be approximately $195 million, assuming a conservative 15% decrease in indirect medical costs when diabetic status improves. In addition, given a 3% interest rate, the 5- and 10-year benefits would be about $920 million and $1.71 billion, respectively.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development
610	Domestic Policy Analysis
703	Nutrition Education and Behavior
805	Community Institutions and Social Services
902	Administration of Projects and Programs
903	Communication, Education, and Information Delivery

Outcome #5

1. Outcome Measures

Finding that hotel demand and supply data from U.S. oil and gas shale plays shows a clear pattern of boom and bust related to drilling activity

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The development of new production methodologies -- horizontal drilling and hydraulic fracturing -- for oil and gas wells revolutionized energy production in the United States, spurring intensive energy development in various locations. The large scale and pace of this activity generated widespread interest about its impacts on host communities. With this new development has come a rapid expansion in housing needs for workers. Historically, developments such as this are prone to boom/bust cycles.

What has been done
A Penn State team examined hotel performance data in seven U.S. oil and gas shale play areas from 2005 to 2016. The hotel industry provides a useful bellwether for the impacts of recent energy development on local economic activity.

Results
Hotel demand and supply data from these shale plays show a clear pattern of boom and bust related to drilling activity. The hotel sector in shale plays initially saw significant increases in demand, with revenues $1.6 billion and 64% above predrilling rates, and major hotel construction and a consequent increase in hotel supply. When drilling activity declined with falling energy prices, this supply boom left the hotel sector in these communities worse off than it would have been without the boom, with occupancy rates below 52%. Short-term energy price forecasts indicate that prices, and thus drilling and hotel demand, likely will not increase significantly. Any future supply still in the planning stages must be carefully considered before proceeding to construction.

This research, and examination of historical boom/bust cycles, suggests that developing hotels early in the cycle brings impressive early revenues, but it is difficult to understand where you are in a boom/bust cycle.

4. Associated Knowledge Areas

KA Code	Knowledge Area
602	Business Management, Finance, and Taxation
603	Market Economics

Outcome #6

1. Outcome Measures

Finding that a higher number of natural disasters experienced historically in a county is correlated with an increase in opioid overdoses

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
There were 72,000 drug opioid-related overdose deaths in 2017 in the U.S. Estimates indicate that drug overdoses cost the country $432 billion in 2015. The opioid crisis is a problem with costs orders of magnitude larger than the costs associated with weather-related disasters in 2017. It cuts across social, economic, and political lines.

What has been done
This study evaluated relationships between socioeconomic factors and opioid overdose deaths in all U.S. counties for the last 50 years. The team used presidentially declared disasters by county from the Federal Emergency Management Agency to determine the effect of natural disasters on opioid deaths. These disasters primarily include weather-related events, such as hurricanes, droughts, and floods.

Results
Along with the overprescribing of opioid-based painkillers, declining farm income, extreme weather, and other natural disasters may affect the abuse of opioids. A higher number of presidentially declared natural disasters experienced historically in a county is correlated with an increase in opioid overdoses. If climatologists? warnings are correct, a changing climate could produce more extreme weather patterns, which could then have an effect on opioid overdoses and deaths.

Income also matters. For each $10,000 reduction in net income per farm, opioid overdoses rose by 10 percent from a national average of 10.2 deaths per 100,000 people to 11.2 deaths per 100,000 people. Opioid-related deaths are increasing in rural counties.

The researchers theorize that one reason this wave of opioid deaths may be higher in rural counties is because of the low number of mental-health treatment facilities in those areas and, perhaps, stigma attached to seeking help in those facilities.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development
723	Hazards to Human Health and Safety

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Public Policy changes
- Government Regulations
- Other (Extramural Funding)

Brief Explanation

Economy
Pennsylvania's shale energy production is an important driver for economic development and revenue generation. As the demand for energy grows and evolves to include more natural gas and reliance on renewables, PA's role as the top producer of shale gas gives PSU a strong rationale for research and outreach in this space.

With increased interest in the downstream utilization of natural gas as the state and national economies transition to lower carbon fuels, shale gas investment will continue to expand. Over $7B is being spent in southwestern PA to support the plastics industry through 2020. We anticipate that amount will double in the next 5 years.

The success of the Ag Entrepreneurship team depends on the economy. The ag economy took many hits over the past year, posing challenges for many of our clients.

Public Policy Changes
Increased interest in environmental, tax, and land planning policy in PA related to regional energy development has elevated the public dialogue on shale gas. Investments are being made to revamp the energy sourcing and distribution models for the changing interest in lower carbon fuels.

Our participation in the PA Energy Horizon scenario building process allows the college to offer science-driven data. The two energy-related outcomes are touted as a basis for emerging energy policy in PA through 2040. A core group of academics, including Penn State, is working with PA government officials to better understand the economic development implications and how academic institutional support could drive positive impacts.

Governmental Regulations
Interest in PA's comprehensive regulatory environment is strong among PA residents affected by shale energy development. The Shale team has offered insights on how the state can transition successfully to a lower carbon energy portfolio.

This interest extends to the many immersive shale trainings we've hosted for international governments. A significant focus has been with Latin American countries with emerging shale energy development.

In the U.S., members of the Penn State Shale team have intensified involvement in TOPCORP, a consortium of 3 universities funded to deliver curricula to state environmental regulatory officials where shale energy is expanding. This program has reached over 37 states and 4 Canadian provinces and continues to receive significant funding.

Funding
The Shale extension team sourced and administered several grants related to pipeline development, outreach education, risk management for agricultural producers, and best management practices (BMPs) for right-of-way disturbances.

They also completed a grant from the U.S. State Department allowing the broader extension team to convey its research-based translational outreach on technical, environmental, socioeconomic, and public policy to the government of Argentina, which is the largest emerging shale gas region in the world outside of North America.

Due to the expansion of investment in downstream natural gas utilization in PA, the Shale team was awarded funds to explore involvement of student interns in mapping out the growth potential of natural gas liquids to polymers in northwest PA.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The strongest evaluation of our programs comes from gathering pre- and post-training responses and the use of retrospective evaluation to assess whether participants actually put into practice lessons learned through extension programs. More statewide extension programs are performing these kinds of meaningful evaluations, so our programs continue to grow stronger and our results continue to become more quantifiable and impactful. We are also finding greater willingness to estimate potential earnings or cost savings as a result of research outcomes.

A customer relationship management tool was implemented in September 2017. That will lead to more consistent implementation of post-event evaluations, which should allow for assessment of change in practice and possibly estimates of economic impacts. These post-event assessments will be used more broadly as time passes.

Key Items of Evaluation

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

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
102	Soil, Plant, Water, Nutrient Relationships	10%		13%	
112	Watershed Protection and Management	10%		15%	
131	Alternative Uses of Land	15%		10%	
133	Pollution Prevention and Mitigation	10%		15%	
135	Aquatic and Terrestrial Wildlife	10%		10%	
403	Waste Disposal, Recycling, and Reuse	15%		12%	
405	Drainage and Irrigation Systems and Facilities	15%		10%	
723	Hazards to Human Health and Safety	15%		15%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	10.6	0.0	11.8	0.0
Actual Paid	6.4	0.0	13.7	0.0
Actual Volunteer	44.5	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**
890199	0	1459682	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
3134013	0	7318983	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
1700406	0	6206397	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

The effects of climate change and how to adapt to it is an important theme in the Environmental Resilience planned program. Climate change research assessed potential effects on corn yields and animal agriculture in Pennsylvania, and on insects. Sociological research looked at migration and regional economic impacts of climate change in the U.S. Extension work includes programs on managing orchards with climate change.

A critical research/extension activity is educational and technical support to help Pennsylvania meet its obligations to Chesapeake Bay water quality. Research examined the possibility of improving bay water quality through payments to farmers for providing ecosystem services, and the simulation of conservation dairy farm practices throughout a small watershed in central Pennsylvania to assess potential impacts on water quality.

The Livestock extension team is educating producers about using fecal egg counts to reduce the use of dewormers. This is part of an improved pasture management system that means less energy is needed to harvest feed for animals and could result in less pollution to water sources from runoff.

The Field and Forage Crops team provided support to conventional and organic corn, soybean, and small grain farmers and forage producers in Pennsylvania to help farms be more profitable and environmentally sustainable. Extension programs highlight the benefits of no-till, cover crops, and interseeding for profitability, nutrient management, and water quality.

2. Brief description of the target audience

- Agricultural Producers/Farmers/Landowners
- Agriculture Services/Businesses
- Business/Industry
- Community Groups
- Education
- General Public
- Government Personnel
- Human Service Providers
- Local, Regional, State, and Federal Agencies
- Nonprofit Associations/Organizations
- Policy Makers

3. How was eXtension used?

Members of the Green Industry, Forestry, and Water Quality and Quantity teams participate in the "Ask an Expert" feature and routinely answer submitted questions. The Master Gardener team answered nearly 1,200 such questions.

Some of the Urban Forestry team used webinars and other educational products.

The Pesticide Education Team used eXtension.org in two ways. They have eight online pesticide applicator recertification courses on that website. These recertification courses were taken by 81 individuals to meet training requirements in order to maintain their pesticide license. Second, a U.S. Environmental Protection Agency grant was obtained through the eXtension Foundation for 2018. The eXtension Foundation was awarded the authority to administer these EPA program monies in support of pesticide safety education programs across the country.

Penn State 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 Extension supports the professional development offered through eXtension.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	81746	119408	33139	1867

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	2

Patents listed

Serial No. 62/594,145; Filed 12/6/2017; Title: Male Fertility-Specific Genetic Diagnostic Assay for Bull Fertility Evaluation and Selection

Serial No. 16/072,756; Filed 07/;26/2018; Title: Sensors for Measuring Water/Solute Content and Thickness of Plant Tissue

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	12	210	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of participants in extension education classes and workshops.
  Not reporting on this Output for this Annual Report

Output #2

Output Measure

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

Year	Actual
2018	1

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Increased knowledge of ecosystem change expected with climate change.
2	Improved strategy for addressing nutrient pollution in Chesapeake Bay.
3	Improve urban environments through green infrastructure research and extension.
4	Improved strategy to address nutrient pollution in Chesapeake Bay
5	Finding that salt, radioactivity, and organic contaminants in road-applied oil and gas wastewater from Pennsylvania and Ohio are often many times higher than drinking water standards
6	Finding that soil may filter antibiotics from treated wastewater, protecting groundwater

Outcome #1

1. **Outcome Measures**

Increased knowledge of ecosystem change expected with climate change.

Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

Improved strategy for addressing nutrient pollution in Chesapeake Bay.

Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

Improve urban environments through green infrastructure research and extension.

Not Reporting on this Outcome Measure

Outcome #4

1. **Outcome Measures**

Improved strategy to address nutrient pollution in Chesapeake Bay

2. **Associated Institution Types**

- 1862 Extension
- 1862 Research

3a. **Outcome Type:**

Change in Knowledge Outcome Measure

3b. **Quantitative Outcome**

Year	Actual
2018	1

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

Issue (Who cares and Why)
A crucial challenge for agriculture is to increase productivity to feed the continuously growing population without deteriorating soil, water, and environmental quality. More emphasis on improved efficiencies, appropriate management of agricultural systems, and improved agronomic and nutrient use practices are needed to address this challenge.

What has been done
Researchers modeled nutrient- and sediment-loading to compare nonpoint pollution from "typical" and "conservation" farms. They simulated effects for all dairy farms in a small drainage in central PA using 1 of 4 scenarios, which differed in land area, feed production, and nutrient input strategies. In the simulations, the conservation farms produce most of the cattle's feed and forage, use no-till planting, and have continuous diverse plant cover, and one scenario includes manure injection.

Results
Compared to the "typical" PA dairy farm, the enhanced conservation dairy-cropping scenarios improved water quality. Over the 12-year simulation, they cut the number of in-stream peaks of nutrients and sediment and reduced average concentration of sediment by 31%, organic N by 41-53%, nitrate by 23%, organic P by 36-45%, and soluble P by 32-43%.

Both conservation scenarios also decreased nitrous oxide emissions by reducing denitrification, but the scenario that included manure injection retarded 91% of nitrogen volatilization that occurred with broadcast manure.

If most dairy farms in PA fully adopt conservation best management practices, the state may be able to achieve its total maximum daily load water-quality target for Chesapeake Bay. But achieving large-scale adoption of conservation dairy-farm practices will not be easy or cheap. Farmers will need access to affordable land to grow more feed and apply manure at lower rates, as well as technical assistance and financial incentives.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation

Outcome #5

1. Outcome Measures

Finding that salt, radioactivity, and organic contaminants in road-applied oil and gas wastewater from Pennsylvania and Ohio are often many times higher than drinking water standards

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
More than a quarter of all U.S. states allow oil and gas (O&G) wastewater to be spread on roads for deicing or dust suppression. Dust from unpaved roads can contribute to respiratory and cardiovascular disease and plant stress.

Northwestern PA townships spread an average of 280,000 liters of O&G wastewater on their roads, saving approximately $70,000 each over the typically priced commercial products for this use.

What has been done
Leveraging funds from USGS, NSF, and Penn State, an interdisciplinary team determined potential environmental and human health impacts from this practice. Analyses of wastewaters spread on roads in northwest PA and northeast OH found salt, radioactivity, and organic chemicals often many times higher than drinking water standards. Bioassays showed that these wastewaters cause toxicity to aquatic organisms such as Daphnia and increase the activity of pathways associated with toxicity in humans.

Results
Lab experiments showed that nearly all of the metals from these wastewaters leach from roads after precipitation events and likely reach ground- and surface water. The wastewaters contain several organic molecules associated with toxicity, as well as a known human carcinogen, radium. This practice released more than four times as much radium to the environment (320 millicuries) in Pennsylvania between 2008 and 2014 as did O&G wastewater treatment facilities and 200 times more radium than O&G spills. State regulations do not currently require radium analysis before these wastewaters can be spread on roads. The authors propose three methods to reduce the impacts of spreading O&G wastewater on roads: 1) require passage through a dedicated O&G wastewater treatment plant before spreading; 2) allow only wastewaters that meet certain standards for radium and diesel- and gas-range organics to be spread; and 3) develop and use affordable nontoxic dust suppressants.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation

135	Aquatic and Terrestrial Wildlife
403	Waste Disposal, Recycling, and Reuse
723	Hazards to Human Health and Safety

Outcome #6

1. Outcome Measures

Finding that soil may filter antibiotics from treated wastewater, protecting groundwater

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Most treated wastewater is discharged by sewage treatment plants into rivers. But most of those facilities cannot completely remove pharmaceuticals such as antibiotics. So many rivers carry low levels of pharmaceuticals that may harm aquatic life. In waterways that provide drinking water, low levels of antibiotics may pose human health risks, contributing to the development of antibiotic resistance. An alternative to discharging treated wastewater into waterways is to spray it on land.

What has been done
Researchers analyzed the fate and transport of three antibiotics important to human health--sulfamethoxazole, ofloxacin, and trimethoprim--in soil and groundwater at the Living Filter, a 50-year-old wastewater reuse system that spray-irrigates treated effluent from the University Park campus's sewage treatment plant on 600 acres of farm and forest.

Results
Results showed that soil in many cases could offer another level of treatment to remove antibiotics from treated wastewater. Each antibiotic behaved differently in soil. The researchers typically found sulfamethoxazole at the highest concentrations in treatment plant effluent, with ofloxacin and trimethoprim at lower concentrations. In soil, ofloxacin concentrations were highest after 7 months without irrigation, but sulfamethoxazole did not reach concentrations higher than ofloxacin until after effluent was continuously applied. Trimethoprim was detected in soil only following 10 weeks of effluent irrigation.

Groundwater concentrations were typically much lower than soil or wastewater effluent concentrations; only sulfamethoxazole was found consistently.

Antibiotics interacted with the soil, and groundwater concentrations were frequently more than a 1,000-fold lower than effluent, so the soil profile appears to be an adequate tertiary treatment for wastewater treatment plant effluent.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
131	Alternative Uses of Land
133	Pollution Prevention and Mitigation
403	Waste Disposal, Recycling, and Reuse
405	Drainage and Irrigation Systems and Facilities
723	Hazards to Human Health and Safety

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.)
- Other (Extramural Funding)

Brief Explanation

Natural Disasters
Weather conditions and/or invasive species can drive clients' requests for programs and advice and can necessitate changes in field research plans and workshops.

Economy
The economy influences clients' interest in and ability to implement tactics suggested. Some clients lack the equipment necessary to implement suggestions.

Tariffs and macroeconomic markets influenced PA lumber/timber markets. More landowners were considering selling timber than usual over concern for the tariffs and what they might do to stumpage prices. Forestry team members fielded additional questions about timber prices and talked people through the processes of valuing timber and hiring foresters, etc.

Economic factors drive clients to participate in free or reduced-fee water testing programs and also affect which water testing packages clients select.

Appropriations changes
Changes in USDA appropriations impact the ability to staff the Urban Forestry team and the amount of operational funding available. As small cuts continue each year in USDA Forest Service funding, the team is facing a point where there will be no operational funds from the grant that funds the Urban Forestry program.

Public Policy changes
The Pesticide Education team devoted time to determining the best approaches to contend with potential dicamba drift issues within Pennsylvania. Industry training for applicators was adopted.

PA Department of Agriculture quarantine compliance policies and IPM strategy guided the Forestry team's activities related to spotted lanternfly, especially the quarantine permit training requirement.

Consideration of a ban on the sale and cultivation of Japanese barberry by the PA Department of Agriculture due to increasing concern about positive association with ticks led to two in-person trainings by the Forestry team on managing woodlot habitat and human behavior in woodlots to mitigate tick risks.

Government Regulations
Worker protection standard updates caused the Pesticide Education team to begin programming focused on respirator fit testing.

Competing Programmatic Challenges
Competing priorities and staffing changes often mean that it's not possible to complete all desired work.

Problems with invasive species that require immediate attention compete with other opportunities for further development of general program efforts. In the counties quarantined for spotted lanternfly, programming demands on Master Gardeners and the Pesticide Education team have increased.

Population changes
New and growing ethnic populations are important clients.

Funding
Some of our programs are affected by funding, either by adding resources to promote them or by shaping the content of the product. Extramural funding may be affected by appropriations.

Extramural funding contracts may be settled significantly after scheduled start dates, requiring changes to research plans.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The strongest evaluation of our programs comes from gathering pre- and post-training responses and the use of retrospective evaluation to assess whether participants actually put into practice lessons learned through extension programs. More statewide extension

programs are performing these kinds of meaningful evaluations, so our programs continue to grow stronger and our results continue to become more quantifiable and impactful. We are also finding greater willingness to estimate potential earnings or cost savings as a result of research outcomes.

A customer relationship management tool was implemented in September 2017. That will lead to more consistent implementation of post-event evaluations, which should allow for assessment of change in practice and possibly estimates of economic impacts. These post-event assessments will be used more broadly as time passes.

Key Items of Evaluation

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

V(A). Planned Program (Summary)

Program # 5

1. Name of the Planned Program

Global Engagement

☑ 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	0%		10%	
202	Plant Genetic Resources	0%		10%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants	0%		10%	
211	Insects, Mites, and Other Arthropods Affecting Plants	10%		10%	
721	Insects and Other Pests Affecting Humans	0%		10%	
723	Hazards to Human Health and Safety	0%		10%	
803	Sociological and Technological Change Affecting Individuals, Families, and Communities	25%		10%	
805	Community Institutions and Social Services	25%		10%	
806	Youth Development	30%		10%	
903	Communication, Education, and Information Delivery	10%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	1.4	0.0	0.3	0.0
Actual Paid	0.1	0.0	0.6	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**
7460	0	102339	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
44503	0	325740	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
37685	0	285827	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

The College of Agricultural Sciences is committed to making advances toward solving some of the world's most pressing problems. To do so, our faculty will continue to collaborate extensively with colleagues and partners from around the world. Such international partnerships are crucial to leveraging scarce research dollars and to gaining access to unique sites, ideas, technologies, and populations. We foster a welcoming climate for international students, scholars, and visitors in which the free flow of information and ideas leads to creative and innovative solutions for the challenges we face as a united global population.

One part of our research and extension work in this planned program addresses global hunger and food security. We are investigating the genetic basis for drought tolerance in crops and sharing that information with plant breeders to promote sustainable food production that minimizes environmental impact. Improving the productivity of plant and animal systems is a balance between maximizing the genetic potential of organisms and minimizing losses due to pests, diseases, and poor agricultural practices.

Another focus of sustainable intensification is on value chains--helping farmers around the world develop new value-added, safe, and nutritious products and getting them to consumers.

Through the Global Engagement planned program, our researchers study diseases of plants and animals important as livelihoods to their growers and in the global economy, and human insect-borne diseases and parasites, such as malaria and zika virus.

Penn State researchers are advancing the role of women in agriculture by taking their successful Pennsylvania Women's Agricultural Network model to Cambodia through a grant from U.S. AID. USDA's continuing support for this model in Pennsylvania made this grant possible.

We are also working to increase opportunities for civic engagement and leadership by international youth, underserved populations, and women. One international team is working to build youth leadership and engagement through research into social issues of the youth's choosing.

2. Brief description of the target audience

- Agricultural Producers/Farmers/Landowners
- Agriculture Services/Businesses
- Business/Industry

- Community Groups
- General Public
- Government Personnel
- Local, Regional, State, and Federal Agencies
- Nonprofit Associations/Organizations
- Special Populations (at-risk and underserved audiences)
- Students/Youth
- USDA
- Volunteer/extension leaders

3. How was eXtension used?

Some team members answered questions through the eXtension program.

Penn State 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 Extension supports the professional development offered through eXtension.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	92	86	0	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	0	11	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of participants in extension education classes and workshops.
  Not reporting on this Output for this Annual Report

Output #2

Output Measure

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

Year	Actual
2018	0

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Enhanced knowledge of drought tolerance in plants.
2	Improved understanding of life cycle of organisms involved in transmission of globally important diseases, such as malaria.
3	Successful strategy for engaging youth, women, or minorities in social action or leadership.
4	Improved understanding of globally important diseases
5	Finding that common bean plants that suppress growth in root thickness (secondary root growth) in favor of growth in root length (primary root growth) forage greater soil volume and acquire more phosphorus
6	Android cell phone app developed to help farmers in sub-Saharan Africa recognize fall armyworm, a new and fast-spreading crop pest

Outcome #1

1. **Outcome Measures**

Enhanced knowledge of drought tolerance in plants.

Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

Improved understanding of life cycle of organisms involved in transmission of globally important diseases, such as malaria.

Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

Successful strategy for engaging youth, women, or minorities in social action or leadership.

Not Reporting on this Outcome Measure

Outcome #4

1. **Outcome Measures**

Improved understanding of globally important diseases

2. **Associated Institution Types**

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

New vector control tools are needed in efforts to reduce malaria transmission worldwide and meet the World Health Organization's control targets. Preliminary evidence shows promise for use of eave tubes in combination with screening of doors and windows in reducing mosquito entry and increasing numbers of mosquitos killed overnight.

What has been done
Researchers found that 90% more mosquitoes (all species) entered experimental huts in Cote d'Ivoire through eave tubes than window slits. Insecticide-treated eave tubes cut mosquito entry by 60%, even with windows open. Mosquitoes in the huts had 64% reduction in blood feeding and were more likely to die, presumably from contact with treated tubes. Anopheles mosquitoes placed in the huts saw six times increase in overnight mortality, suggesting contact with treated eave tubes as they tried to leave.

Results
Using leveraged funds from the Bill & Melinda Gates Foundation, this study showed that treated eave tubes may be an effective way to control Anopheles mosquitoes. Their effectiveness even with windows open may be important because it will be easier and less expensive to install eave tubes alone rather than in combination with window screening.

The research team found no evidence of deflection of mosquitoes from huts with screening and/or eave tubes to adjacent unmodified huts. This is important because it is unlikely that all houses will be covered by the intervention, and unprotected households should not be disadvantaged by those that adopt the technology.

The direct cost of malaria is estimated to be at least $12 billion per year.

4. Associated Knowledge Areas

KA Code	Knowledge Area
721	Insects and Other Pests Affecting Humans
723	Hazards to Human Health and Safety

Outcome #5

1. Outcome Measures

Finding that common bean plants that suppress growth in root thickness (secondary root growth) in favor of growth in root length (primary root growth) forage greater soil volume and acquire more phosphorus

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Most soils throughout the world are phosphorus deficient. Root traits that improve phosphorus acquisition help improve the efficiency of fertilizer uptake for farmers here in the U.S., and also benefit farmers in developing countries who do not have access to phosphate fertilizers.

What has been done
Penn State plant scientists are identifying root traits that improve nutrient uptake efficiency. The researchers use common bean because it is one of the most important crops for global food security, with greater volume for direct human consumption than any other grain legume. It is especially important throughout the developing world, where people don't have wide access to animal protein.

Results
The team found that common bean plants that suppress growth in root thickness (secondary root growth) in favor of growth in root length (primary root growth) forage greater soil volume and acquire more phosphorus. The findings have implications for plant breeders and improving crop productivity in nutrient-poor soils. The team collaborates with plant breeders who can use this information to develop new cultivars with greater ability to take up phosphorus, and cultivars with improved yields in acidic, low-phosphorus soils.

4. Associated Knowledge Areas

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

Outcome #6

1. Outcome Measures

Android cell phone app developed to help farmers in sub-Saharan Africa recognize fall armyworm, a new and fast-spreading crop pest

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Fall armyworm larvae have caused an estimated $2.5 billion-$6.2 billion in damage annually to maize in sub-Saharan Africa since the pest arrived there in 2016. It has infested millions of hectares of maize and threatens the food security of more than 300 million people.

What has been done
With leveraged funding from UN FAO and in collaboration with Google, a Penn State team developed an Android app called Nuru to help African farmers recognize fall armyworm so they can take immediate steps to destroy it and curb its spread. With the app, growers can hold the phone next to a plant showing symptoms, and Nuru uses artificial intelligence algorithms and the phone's camera to confirm immediately whether fall armyworm has caused the damage. The app works even without internet access.

Results
Nuru is embedded in the PlantVillage app, which is a free app built at Penn State in collaboration with UN FAO, international ag research consortium CGIAR, and other public institutions, and soon will be linked into FAO's FAMEWS app.

Once farmers connect their device online, Nuru will interface with the FAMEWS app to upload the collected data, which will be validated by national fall armyworm focal points and added to a global, web-based database.

The database analyzes data from across Africa to give a real-time overview with maps of fall armyworm infestations and the measures most effective in reducing its impact.

Penn State and FAO scientists are working on new features to make Nuru an even more powerful ally against fall armyworm. Nuru will soon be able to speak to farmers in their own language, walking them through the process of checking their crops for fall armyworm infestations, reporting armyworm population levels, and advising them how to fight the pest.

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
903	Communication, Education, and Information Delivery

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
Natural disasters allow the rapid spread of diseases and can damage equipment, such as drinking water treatment systems, that is essential for public health.

Economy
The global economy influences political instability, and lack of opportunity can incite radical groups, disempower women and minorities, and discourage peace-building activities.

Appropriation changes, public policy changes, competing public priorities, and competing programmatic challenges

Changes in appropriations and public policy, and competing public priorities and programmatic challenges can influence the amount of foreign aid available.

Government regulations
U.S. and foreign government regulations can influence the feasibility and necessity of various projects.

Funding
Some of our programs are affected by 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 strongest evaluation of our programs comes from gathering pre- and post-training responses and the use of retrospective evaluation to assess whether participants actually put into practice lessons learned through extension programs. More statewide extension programs are performing these kinds of meaningful evaluations, so our programs continue to grow stronger and our results continue to become more quantifiable and impactful. We are also finding greater willingness to estimate potential earnings or cost savings as a result of research outcomes.

A customer relationship management tool was implemented in September 2017. That will lead to more consistent implementation of post-event evaluations, which should allow for

assessment of change in practice and possibly estimates of economic impacts. These post-event assessments will be used more broadly as time passes.

Key Items of Evaluation

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

V(A). Planned Program (Summary)

Program # 6

1. Name of the Planned Program

Integrated Health Solutions

☑ 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
301	Reproductive Performance of Animals	0%		12%	
303	Genetic Improvement of Animals	0%		12%	
304	Animal Genome	0%		12%	
503	Quality Maintenance in Storing and Marketing Food Products	15%		0%	
504	Home and Commercial Food Service	15%		0%	
701	Nutrient Composition of Food	10%		15%	
702	Requirements and Function of Nutrients and Other Food Components	10%		10%	
703	Nutrition Education and Behavior	15%		10%	
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins	10%		0%	
723	Hazards to Human Health and Safety	10%		15%	
724	Healthy Lifestyle	15%		14%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	8.7	0.0	14.1	0.0
Actual Paid	39.6	0.0	10.9	0.0
Actual Volunteer	15.1	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**
426411	0	1774226	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1647425	0	8932079	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
4247620	0	18741555	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

The food processing industry is an important economic driver in Pennsylvania, and much of the research in this planned program contributes to improved and safer food. Food scientists examined the effects of added sugar, salt, or spices on vegetable consumption in babies and teens; safe sausage-making techniques; and locating and controlling Listeria monocytogenes in fruit packing houses, among many other topics.

Functional food-related research in the College includes mouse studies showing that eating mushrooms may reduce the incidence of diabetes, and that dietary broccoli affects gut microbial community structure and attenuates chemically induced colitis. These findings may help advance our knowledge of these diseases in humans.

Other researchers explored salmonella; E. coli; avian influenza; malaria, zika, and other tropical diseases; and selenium deficiency, among other diseases, disorders, and deficiencies.

The Animal Welfare and Health extension team has conducted research to better understand the dynamics of antimicrobial resistance in dairy calves and the impact of several management factors. They have incorporated their findings into educational materials for producers, nutritionists, and vets. Dairy breeding and genetics are other areas of active research in veterinary and biomedical sciences.

The requirements of the Food Safety Modernization Act are important drivers of our extension programming in this planned program. Farms with over $25,000 in sales growing fresh produce likely to be eaten raw are required under the Produce Safety Rule to meet farm food safety standards and keep certain records. Under the Preventive Controls Rules for Human or Animal Food, all FDA-registered facilities are required to develop and implement preventive control food safety systems. Faculty have developed trainings to meet these needs. These offerings are well received and expanding. Extension teams are also providing industry partners help in writing Preventive Controls plans. These partners value our ability to provide continuing unbiased support in helping them implement best practices learned in trainings.

The ServSafe and Retail Manager training curricula are frequently presented to meet regulatory requirements for commercial food service operations. We offer specialized food safety trainings for specific industries as requested.

Extension work in Consumer Food Safety includes frequent offerings of Cooking for Crowds, for volunteer organizations that prepare and serve food to the public, and workshops by Master Food Preserver

volunteers, who teach home food preservation.

The Health and Wellness extension team offers Dining with Diabetes, Strong Women, Everybody Walks, Seniors Eating Well, and Mediterranean Cuisine Comes to You.

We are offering an expanding number of food safety and animal care trainings in Spanish to meet the growing need, and we are translating more materials into additional languages as well.

2. Brief description of the target audience

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

3. How was eXtension used?

One faculty member has been directly involved with eXtension.org as a member of the program team for DAIReXNET since the early 2000s. He was the animal health domain leader for a period of time, then continued as part of the programming team. He has worked with the team to identify speakers for recorded webinars and provided two different lectures for webinars on nutrition and lameness and understanding mastitis. Another faculty member has also provided webinar-recorded lectures on the topic of lameness and answered a number of "Ask the Expert" questions.

One extension educator and one retired extension educator on the Health and Wellness team attended an eXtension Diversity Program Development one-day training in Cincinnati, OH.

The Industrial Food Safety & Quality team answered approximately 50 questions that were posted on eXtension.

Penn State 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 Extension supports the professional development offered through eXtension.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	46917	13529	7918	277

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	10

Patents listed

Serial No. PCTUS2017/067054; Filed 12/18/2017; Title: Methods for Improved Reproducing Management of Ruminant Ungulates

Serial No. 62/618, 891; Filed 1/18/2018; Title: Mycobacterium Paratuberculosis Immunodiagnostic Antigens, Methods, and Kits Comprising Same

Serial No. 62/578, 805; Filed 10/30/2017; Title: Targeting Peptide to Deliver a Compound to Oocytes

Serial No. 62/724, 468; Filed 8/29/2018; Title: Compositions and Methods for Use in Controlling Mosquito-borne Viruses

Serial No. 62/639, 771; Filed 3/7/2018; Title: Stabilization of Carrageenan Free Chocolate Milk

Serial No. 62/698,423; Filed 7/16/2018; Title: Compounds, Compositions and Methods for Coloring Edible Materials

Serial No. 62/733, 951; Filed 9/20/2018; Title: Skim Milk Powders with Enhanced Foaming Properties

Serial No. 16/040, 592; Filed 7/20/2018; Title: Modulation of CCR10 Signals for Treatment of Skin and Intestinal Inflammatory Diseases and Infection

Serial No. 62/596, 897; Filed 10/9/2017; Title: Paramyxovirus Virus-like Particles as Protein Delivery Vehicles

Serial No. PCT/US2018/046027; Filed 8/9/2018; Title: Low-Temperature Plasma Catheter for Less-Invasive, Localized Treatment of Endocarditis and Atherosclerosis

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	1	175	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of participants in extension education classes and workshops.
  Not reporting on this Output for this Annual Report

Output #2

Output Measure

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

Year	Actual
2018	4

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of people trained in safe food handling techniques.
2	Change in knowledge related to humane or efficient livestock housing and handling.
3	Change in knowledge related to our understanding of a disease mechanism, diagnostic testing, prevention strategy, or treatment for a livestock and/or human disease.
4	Increased knowledge of livestock genomics to potentially enhance performance and increase efficiency.
5	Increased knowledge of livestock genomics to potentially enhance performance and increase efficiency: Provisional patent application filed for a male fertility-specific genetic diagnostic assay for bull fertility evaluation and selection
6	Minimum potential savings (in $) in health care costs averted if one case of foodborne illness is avoided at each Pennsylvania food facility where a manager received Penn State extension's ServSafe food safety training in this program year
7	Change in knowledge related to our understanding of a disease mechanism, diagnostic testing, prevention strategy, or treatment for a livestock and/or human disease: Finding that mice fed a broccoli-supplemented diet were better able to tolerate digestive issues similar to symptoms of leaky gut and colitis than mice fed a typical diet
8	Change in knowledge related to our understanding of a disease mechanism, diagnostic testing, prevention strategy, or treatment for a livestock and/or human disease: Finding that mushrooms are rich in antioxidants that may have anti-aging potential
9	Finding that injuries to lower extremities were 16% higher per play on synthetic turf than natural turf during National Football League games, with implications to play at all ability levels and across many sports

Outcome #1

1. **Outcome Measures**

   Number of people trained in safe food handling techniques.

   Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

   Change in knowledge related to humane or efficient livestock housing and handling.

   Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

   Change in knowledge related to our understanding of a disease mechanism, diagnostic testing, prevention strategy, or treatment for a livestock and/or human disease.

   Not Reporting on this Outcome Measure

Outcome #4

1. **Outcome Measures**

   Increased knowledge of livestock genomics to potentially enhance performance and increase efficiency.

   Not Reporting on this Outcome Measure

Outcome #5

1. **Outcome Measures**

   Increased knowledge of livestock genomics to potentially enhance performance and increase efficiency: Provisional patent application filed for a male fertility-specific genetic diagnostic assay for bull fertility evaluation and selection

2. **Associated Institution Types**

   - 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Infertility and subfertility are common problems in cattle and other livestock species. Low breeding efficiency of sires can mean that repeated inseminations are needed, which drives up the overall cost of insemination and drives down the efficiency of livestock reproduction. A cow that has a fertile heat but is not impregnated until the following heat cycle consumes extra resources.

What has been done
A Penn State team addressed the bull fertility issue by identifying molecular genetic markers and designing a male fertility-specific assay to evaluate a bull's fertility potential and help animal breeders make decisions based on the animal's male fertility genotype.

This invention relates to DNA markers (single-nucleotide polymorphisms [SNPs]) associated with enhanced male fertility in bulls that are otherwise assessed to be fertile, and haplotypes formed from such SNPs.

Results
This invention, for which a provisional patent was filed, provides a user-friendly and cost-effective method for identifying soon after birth bovine males that will produce semen demonstrating a higher rate of fertilization through artificial insemination or natural mating in dairy and beef cows.

A group of 96 SNPs selected from the prototype SNP-chip described above was used to produce the male fertility-specific genetic diagnostic assay. The selection of markers is based on the correlation and accuracy of SNPs with traits of semen/sperm quality and bull fertility. Although the number of markers (96) is set in the assay, the actual SNPs vary depending on the genetic background of the cattle, including species, type (dairy vs. beef), and breed (Holstein, Angus, etc.). The flexibility in marker contents allows the assay to be optimized for maximum genetic improvement in male fertility selection.

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of Animals
303	Genetic Improvement of Animals
304	Animal Genome

Outcome #6

1. Outcome Measures

Minimum potential savings (in $) in health care costs averted if one case of foodborne illness is avoided at each Pennsylvania food facility where a manager received Penn State extension's ServSafe food safety training in this program year

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	4300000

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The Centers for Disease Control and Prevention in their Prevention Status Report of February 2016 identified four key Food Code provisions for reducing the risk of foodborne illness outbreaks in food service operations. One of these requirements is for a certified food protection manager. The report indicates that manager certification is related to increased food safety knowledge, safer restaurant food preparation practices, better inspection scores, and fewer foodborne illness outbreaks.

What has been done
Penn State's Retail Food Service and Consumer Food Safety extension team delivered the ServSafe Manager Food Safety Certification training to people representing 1,098 different food service operations this program year. The program teaches how to safely prepare, store, handle, and purchase food; how to manage pests; how to clean and sanitize a food facility; and about foodborne microorganisms and allergens, and personal hygiene.

Results
According to a 2018 article in the journal Public Health Reports, the economic burden of a single foodborne illness outbreak to a restaurant can range from $3,968 to $2.2 million for a fast food, fast-casual, or casual dining restaurant, depending on type of pathogen, number of people affected, lost revenue, lawsuits, legal fees, and other costs. If one case of foodborne illness is prevented in each of the 1,098 Pennsylvania facilities where managers received ServSafe food safety training from Penn State Extension in this program year, the total economic savings could range from $4.3 million to $2.8 billion per year.

4. Associated Knowledge Areas

KA Code	Knowledge Area
503	Quality Maintenance in Storing and Marketing Food Products
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins
723	Hazards to Human Health and Safety

Outcome #7

1. Outcome Measures

Change in knowledge related to our understanding of a disease mechanism, diagnostic testing, prevention strategy, or treatment for a livestock and/or human disease: Finding that mice fed a broccoli-supplemented diet were better able to tolerate digestive issues similar to symptoms of leaky gut and colitis than mice fed a typical diet

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Gastrointestinal problems such as a leaky gut can lead to inflammation, which can then lead to other conditions, such as arthritis and heart disease. It's important to maintain a good intestinal barrier because this helps protect the intestines from toxins and harmful microorganisms, while allowing nutrients to pass into the system.

What has been done
In a study, when mice ate broccoli with their regular diet, they were better able to tolerate digestive issues similar to symptoms of leaky gut and colitis than mice that were fed a typical diet. Other cruciferous vegetables, like brussels sprouts and cauliflower, may have similar gut health properties. The key to the process may be the aryl hydrocarbon receptor (AHR) in the gut, which helps regulate the body's reaction to certain environmental contaminants and triggers responses to toxins.

Results
The research team found that cruciferous vegetables contain an organic chemical compound called indole glucosinolates, which breaks down into other compounds, including indolocarbazole (ICZ) in the stomach. When ICZ binds to and activates the AHR in the intestinal lining, it helps maintain a healthy balance in the gut flora and enhances host barrier function. This may help

prevent diseases, such as various cancers and Crohn's disease, caused by inflammation in the lining of the gut.

Humans would have to eat about 3.5 cups of broccoli each day to experience a similar effect. That's a fairly large amount, but some varieties of broccoli have twice as much of the protective chemical as the variety the team tested. Brussels sprouts have three times as much of the chemical, which would mean a daily cup of brussels sprouts could get us to the same protective level.

4. Associated Knowledge Areas

KA Code	Knowledge Area
701	Nutrient Composition of Food
702	Requirements and Function of Nutrients and Other Food Components
703	Nutrition Education and Behavior
724	Healthy Lifestyle

Outcome #8

1. Outcome Measures

Change in knowledge related to our understanding of a disease mechanism, diagnostic testing, prevention strategy, or treatment for a livestock and/or human disease: Finding that mushrooms are rich in antioxidants that may have anti-aging potential

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
When the body uses food to produce energy, it also causes oxidative stress because some free radicals are produced. Free radicals are oxygen atoms with unpaired electrons that cause damage to cells, proteins, and even DNA as these highly reactive atoms travel through the body seeking to pair up with other electrons. Replenishing antioxidants in the body through certain foods may help protect against this oxidative stress and the health problems it can bring.

What has been done

Analysis revealed that mushrooms have high amounts of two antioxidants, ergothioneine and glutathione, important in fighting aging. Mushrooms are the highest dietary source of these two antioxidants together. The amounts of the two compounds varies greatly among mushroom species. Porcini mushrooms, a wild variety, contained the highest amount of the two compounds among the 13 species tested. The more common white button mushrooms had less of the antioxidants, but higher amounts than most foods.

Results
The body has mechanisms such as ergothioneine and glutathione to control most free radicals, but eventually enough accrue to cause damage associated with the diseases of aging, such as cancer and Alzheimer's.

Future research may look at any role that these compounds have in decreasing the likelihood of diseases such as Parkinson's and Alzheimer's. The data are preliminary, but countries that have more ergothioneine in their diets, such as Italy, also have lower incidences of neurodegenerative diseases, while countries such as the U.S., where people consume less ergothioneine, have a higher probability of these diseases. The research team doesn't yet know if this is a correlative or causative relationship. The difference between countries with high and low rates of neurodegenerative diseases is about 3 milligrams per day, about five button mushrooms daily.

This finding might drive up demand for Pennsylvania mushrooms, currently valued at more than $550 million yearly.

4. Associated Knowledge Areas

KA Code	Knowledge Area
701	Nutrient Composition of Food
724	Healthy Lifestyle

Outcome #9

1. Outcome Measures

Finding that injuries to lower extremities were 16% higher per play on synthetic turf than natural turf during National Football League games, with implications to play at all ability levels and across many sports

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
There is growing awareness of and concern for how turf type affects athlete health and safety at all levels of play and across many sports.

Biomechanical studies show that natural turf releases cleats more readily than does synthetic turf. Sports medicine specialists hypothesized that this places a greater load on the foot on synthetic turf and contributes to lower extremity injuries.

What has been done
A team of turf specialists, sports medicine doctors, and associated professionals analyzed injuries to lower extremities during 2012-2016 regular season games of the National Football League. They analyzed the rate of lower body injuries for any injury causing missed participation in football, with a separate accounting for injuries resulting in at least 8 days missed.

Results
Injuries to lower extremities were 16% higher per play on synthetic turf than natural turf during National Football League games, both for injuries causing any missed participation and those causing at least 8 missed days. This result became more pronounced in analysis of injuries closer to the turf (foot/ankle) and in analysis of noncontact/surface contact injuries. The results support the hypothesized biomechanical mechanism suggesting greater injury to lower extremities on synthetic turf.

The type of footwear used on various playing surfaces may be important in minimizing injuries.

This finding has relevance to play at all ability levels because synthetic turf is being used more and more for sports playing surfaces, across many different sports.

4. Associated Knowledge Areas

KA Code	Knowledge Area
723	Hazards to Human Health and Safety

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

Natural Disasters
Many of our participants will not travel in bad weather, which makes scheduling classes a challenge in the winter, particularly in rural counties.

Economy
Many potential participants in Health and Wellness programs live on a fixed income and paying for a class is prohibitive. Dining with Diabetes does not accept insurance reimbursement.

Government Regulations
The Food Safety Modernization Act (FSMA) has had a major impact on the food supply chain. Growers of fresh produce likely to be eaten raw on farms with over $25,000 in sales are required under the Produce Safety Rule to meet farm food safety standards and keep certain records. Under the Preventive Controls Rules for Human or Animal Food, all FDA-registered facilities are required to develop and implement preventive control food safety systems. A key requirement in each rule is obtaining knowledge through training or experience on the regulatory requirements. This is new to produce growers. Although individuals working in larger businesses may already be familiar with industrial food safety standards, smaller human- and animal-food manufacturing facilities may not have had a formalized food safety control program in place.

Competing Public Priorities
With attention to food safety and quality, there is continued demand for other food industry technical programs, including those required by industry audit standards or sought by companies trying to improve their food safety and quality systems.

Competing Programmatic Challenges
Many educators in Health and Wellness programs are juggling several major programs and supervising paraprofessionals over a large geographic area.

Loss of staff through retirements and attrition has left many counties without the oversight of Family and Consumer Sciences educators to administer Health and Wellness programs.

Population Changes
We have recently trained several educators to deliver the Dining with Diabetes program in Spanish, and the program was successfully offered in Montgomery and Lancaster Counties in 2017-2018. The online Dining with Diabetes course shows promise as an alternative for underserved populations, particularly those under 40.

In addition to food industry partners, training workshops have been attended by regulators, including FDA inspectors, as well as by members of USDA Foreign Agricultural Service. They have found the university-based training programs to provide a high level of technical accuracy and sufficient depth to enhance inspector knowledge.

The only trained "Strong Women Ambassador" retired, so this limited having any new instructor training again this year.

Funding
External funding allows us to provide more program resources than we could with only state resources.

Grant funds for the Strong Women program provided weights, training for site leaders, and wages for new site leaders in several rural counties.

Pennsylvania's wine industry has received significant grant funding. Nearly half has gone to research, which is vital to the continued, successful growth of the state's rapidly expanding wine industry.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The strongest evaluation of our programs comes from gathering pre- and post-training responses and the use of retrospective evaluation to assess whether participants actually put into practice lessons learned through extension programs. More statewide extension programs are performing these kinds of meaningful evaluations, so our programs continue to grow stronger and our results continue to become more quantifiable and impactful. We are also finding greater willingness to estimate potential earnings or cost savings as a result of research outcomes.

A customer relationship management tool was implemented in September 2017. That will lead to more consistent implementation of post-event evaluations, which should allow for assessment of change in practice and possibly estimates of economic impacts. These post-event assessments will be used more broadly as time passes.

Key Items of Evaluation

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

V(A). Planned Program (Summary)

Program # 7

1. Name of the Planned Program

Positive Future for Youth, Families, and Communities

☑ 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
723	Hazards to Human Health and Safety	15%		20%	
724	Healthy Lifestyle	15%		15%	
802	Human Development and Family Well-Being	15%		15%	
803	Sociological and Technological Change Affecting Individuals, Families, and Communities	15%		15%	
805	Community Institutions and Social Services	15%		10%	
806	Youth Development	10%		15%	
903	Communication, Education, and Information Delivery	15%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	20.7	0.0	0.7	0.0
Actual Paid	30.4	0.0	0.5	0.0
Actual Volunteer	132.6	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**
1728365	0	54573	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
5785857	0	339496	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
9748636	0	106880	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Penn State's nationally renowned farm safety and health team offered trainings for emergency responders that ultimately saved a farmer's life when he was trapped in a rapidly filling grain bin. This team continues to offer general and youth farm safety demonstration days and other events. They meet regularly with the Amish Safety Committee to gather feedback to develop programming and interventions, such as for protecting children from falls associated with hay holes and from equipment run-overs.

Penn State's UNESCO Chair for Community, Leadership, and Youth Development headed a program to develop youth as researchers of solutions to social problems. His team also studied predictors of leadership skills among Pennsylvania youth.

One of our rural sociology teams studied the economic value of poor mental health days. Another team explored various aspects of poverty--how marriage, work, and racial inequalities affect poverty; racial diversity and poverty; and the spatial concentration of America's rural poor.

A long-standing extension program in this planned program is Pennsylvania AgrAbility, through which farmers, farm workers, and farm family members can receive free consultation and advice about assistive technology and safe work practices to address physical and/or mental health issues and enable them to continue farming. With leveraged funds from the state, many farmers in this program receive assistive equipment at no cost to them.

The 4-H Positive Youth Development team is researching and preparing material for educators and volunteers to access in support of youth with special needs. Their Local Government Day and State 4-H Capital Day taught youth about local and state government, legislative processes, advocacy, parliamentary procedure, and how to read/vote on bills.

The 4-H Science team's computer science program recruited and trained 110 teen leaders to be Teen Tech teachers. They in turn taught 1,350 youth how to code in various computer software experiences. These youth learned how computer science is used to solve problems and about jobs in computer science. Through the Bayer Science Matters team, a group of teens developed an app to enable stable owners and horse boarders to manage their horses by collecting and sharing veterinary, feed, exercise, and owner information.

Other extension activities include a focus on diabetes education, grand-families, Better Kid Care, PROSPER, the Strengthening Families Program for Parents and Youth, and the Bringing the Protective Factors Framework to Life in Your Work curriculum.

2. Brief description of the target audience

- Agricultural producers/Farmers/Landowners
- Agriculture Services/Businesses
- Business/Industry
- Community Groups
- Education
- General Public
- Government Personnel
- Human Service Providers
- 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 continues to be the lead institution for the Farm and Ranch in eXtension for Safety and Health (FReSH) Community of Practice. The CoP consists of over 100 members who are involved in developing and reviewing content for the site. The FReSH site is the official ag safety and health website for the Agricultural Safety and Health Council of America (ASHCA), which is linked to industry. Grant funds were used to host the annual FReSH Leadership Team meeting in May in Washington, D.C. Our involvement in eXtension has enabled our program to generate approximately $2 million over an eight-year period, which provides funds for staff, program development, resource production, and expansion. USDA-NIFA emphasizes the use of eXtension in their youth farm safety grant applications, which has given Penn State an advantage in applying for these grants. Over the past year, we have increased our collaborations with the University of Missouri and the Women in Agriculture Learning Network to work on agricultural safety and health information for women involved in production agriculture. Additional funds are generated for FReSH activities through an online course.

Penn State 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 Extension supports the professional development offered through eXtension.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	118503	674260	86637	7140

2. Number of Patent Applications Submitted (Standard Research Output)
Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	4	9	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of participants in extension education classes and workshops.
  Not reporting on this Output for this Annual Report

Output #2

Output Measure

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

Year	Actual
2018	0

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Additional way to educate about farm safety.
2	Participants will show improvement in one or more key health metrics.
3	Participants will show measurable changes in life skills.
4	Youth and families will illustrate skills in healthy lifestyles.
5	Farmer's life saved because first responders had appropriate farm-rescue training
6	Dollar value of leveraged funds from the Pennsylvania Office of Vocational Rehabilitation since 2005 to support the Pennsylvania AgrAbility program by providing assistive technology that allows clients to continue farming

Outcome #1

1. **Outcome Measures**

   Additional way to educate about farm safety.

   Not Reporting on this Outcome Measure

Outcome #2

1. **Outcome Measures**

   Participants will show improvement in one or more key health metrics.

   Not Reporting on this Outcome Measure

Outcome #3

1. **Outcome Measures**

   Participants will show measurable changes in life skills.

   Not Reporting on this Outcome Measure

Outcome #4

1. **Outcome Measures**

   Youth and families will illustrate skills in healthy lifestyles.

   Not Reporting on this Outcome Measure

Outcome #5

1. **Outcome Measures**

   Farmer's life saved because first responders had appropriate farm-rescue training

2. **Associated Institution Types**

   - 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Responding to an agricultural emergency is very different than responding to an automobile incident or fire. These issues are addressed through a specialized first responder training program through the Penn State Ag Safety and Health Program. Farmers are at high risk for serious and life-threatening injuries by the nature of their work.

What has been done
A Pennsylvania farmer trapped in a grain bin was rescued by first responders who knew how to save him thanks to training from Penn State Extension. In Northumberland County a farmer was loading a truck, noticed the grain was not flowing as it should, and entered the bin. A crust had developed on top of the corn, and the void beneath collapsed. He became trapped, with corn continuing to enter the auger. Another worker found him and called for help.

Results
The farmer's life was saved because of training the first responders received through a PSU Extension program. The training is important because most commonly used rescue techniques may not work in farm-rescue situations. Education of farmers and first responders is key in keeping farmers safe.

According to the National Rollover Protective Structure Rebate Program, the cost of an agricultural-related fatality such as grain bin entrapment is estimated to be $922,210. The death of the primary operator on a farm has a dramatic impact on farm income and whether the farm operation even survives. The loss of a farmer also affects the community's economy (e.g., feed store, equipment dealership, or even the sale of a farm). Increasing the availability of farm safety training can save lives and is beneficial to the economy of Pennsylvania's agricultural sector.

4. Associated Knowledge Areas

KA Code	Knowledge Area
723	Hazards to Human Health and Safety
903	Communication, Education, and Information Delivery

Outcome #6

1. Outcome Measures

Dollar value of leveraged funds from the Pennsylvania Office of Vocational Rehabilitation since 2005 to support the Pennsylvania AgrAbility program by providing assistive technology that allows clients to continue farming

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	2440000

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The average U.S. farmer is 58 years old, and farming is the seventh most dangerous job. Many farmers, farm family members, or farm workers have a chronic health condition or disability--arthritis is most common. Pennsylvania AgrAbility provides no-cost informational assistance to those facing physical or cognitive challenges in an industry that typically requires an able body. The team also educates service providers about AgrAbility, links farmers to resources, and promotes farm safety.

What has been done
Penn State Extension partners with the Office of Vocational Rehabilitation in the Pennsylvania Department of Labor and Industry to support Pennsylvania farmers in maintaining independent living, an enhanced quality of life, and farm financial sustainability. AgrAbility specialists offer recommendations to clients, such as changing to a field-model wheelchair, adopting assistive technologies, implementing universal design for ease of use, and urging safe work methods.

Results
Since 2005, Pennsylvania AgrAbility has conducted more than 500 customized and confidential on-farm assessments to suggest ways to adapt tools or work sites to allow farmers with disabilities to continue farming.

Through collaboration and leveraged funds from the Office of Vocational Rehabilitation (OVR) in the Pennsylvania Department of Labor and Industry, the consultation and development of formal recommendations are free to farmers in the state.

Since 2005 Pennsylvania AgrAbility has received $1.62 million in USDA funds. The staff have leveraged that with $2.44 million worth of assistive technology provided to clients from OVR.

Says one recent recipient of AgrAbility support: "What we do around the farm is hard stuff, and my husband and I were facing some tough questions about the future of our farm with my limitations. I need to be there to help. I want to be there. With the assistance I received, we no longer have those questions. Our farm has a bright future ahead."

4. Associated Knowledge Areas

KA Code	Knowledge Area
723	Hazards to Human Health and Safety
724	Healthy Lifestyle
802	Human Development and Family Well-Being
803	Sociological and Technological Change Affecting Individuals, Families, and Communities
805	Community Institutions and Social Services

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Public Policy changes
- Competing Public priorities
- Other (Extramural Funding)

Brief Explanation

Economy
Funding is limited to conduct agricultural safety and health trainings and for emergency responders to participate in agricultural rescue training.

Cutbacks in funding for Extension have resulted in the loss of educator positions from the Family Well-being team. There are fewer educators with expertise in early child care and education across the state to reach the same number of providers. The growth in the Better Kid Care On Demand program is evidence of the growth in this area of programming.

PROSPER programs are fully sustained by community teams. Since funding sources are limited, funding PROSPER infrastructure and programs has been challenging.

Some 4-H clientele could not participate in statewide programming because of costs. With less money available to support the 4-H organization as a whole, more money needs to be raised above and beyond the typical fundraising goals.

Public policy changes
The Commonwealth of PA has updated the Keystone Stars childcare programs standards, including expectations for professional development. Outside of required orientation and health and safety training, programs and caregivers now have no required trainings or categories of required training. Each center develops a Continuing Quality Improvement (CQI) program unique to each setting and identifies areas of need. It is challenging to proactively plan trainings when the contents of the CQI plans are not known to educators.

Competing public priorities
There are many activities, programs, and organizations competing for the time of our youth and volunteers. Volunteers are able to deliver programming only to the youth we draw to the program, so the number of youth affected can be limiting. Some counties struggle to get enough volunteers to help deliver programming and start and maintain clubs.

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 strongest evaluation of our programs comes from gathering pre- and post-training responses and the use of retrospective evaluation to assess whether participants actually put into practice lessons learned through extension programs. More statewide extension programs are performing these kinds of meaningful evaluations, so our programs continue to grow stronger and our results continue to become more quantifiable and impactful. We are also finding greater willingness to estimate potential earnings or cost savings as a result of research outcomes.

A customer relationship management tool was implemented in September 2017. That will lead to more consistent implementation of post-event evaluations, which should allow for assessment of change in practice and possibly estimates of economic impacts. These post-event assessments will be used more broadly as time passes.

Key Items of Evaluation

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

VI. National Outcomes and Indicators

1. NIFA Selected Outcomes and Indicators

Childhood Obesity (Outcome 1, Indicator 1.c)	
0	Number of children and youth who reported eating more of healthy foods.
Climate Change (Outcome 1, Indicator 4)	
0	Number of new crop varieties, animal breeds, and genotypes whit climate adaptive traits.
Global Food Security and Hunger (Outcome 1, Indicator 4.a)	
0	Number of participants adopting best practices and technologies resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources.
Global Food Security and Hunger (Outcome 2, Indicator 1)	
0	Number of new or improved innovations developed for food enterprises.
Food Safety (Outcome 1, Indicator 1)	
0	Number of viable technologies developed or modified for the detection and
Sustainable Energy (Outcome 3, Indicator 2)	
0	Number of farmers who adopted a dedicated bioenergy crop
Sustainable Energy (Outcome 3, Indicator 4)	
0	Tons of feedstocks delivered.