FY 2020 Annual Report of Accomplishments and Results

Pennsylvania
The Pennsylvania State University

I. Report Overview

The NIFA reviewer will refer to the executive summary submitted in your FY 2020 Plan of Work located in the Institutional Profile. Use this space to provide updates if needed.

1. Executive Summary (Optional)

The Executive Summary submitted for the FY2020-2024 Plan of Work remains accurate. The following information is new or updated information from this reporting year (FY2020) to augment what was previously submitted and approved.

Evolving outlook on the future of agriculture
The COVID-19 pandemic and the racial unrest of summer 2020 have exposed and exacerbated issues of agricultural and food supply chains, workforce challenges, impacts on youth education, public health, and internet connectivity, among others.

To help meet these challenges, we are developing a conceptual framework based on the science of agricultural sustainability--defined as the integration of natural and social sciences to inform practice and policy for productive, working landscapes, healthy watersheds, and resilient economies. This innovative approach to agricultural research, engagement, and education centers on the impacts and synergies of contiguous rural and urban landscapes. From forests to crops to animal facilities, the location of economically significant agricultural systems in Pennsylvania adjacent to and sometimes within highly populated regions creates distinct challenges and opportunities for the integration of natural and social sciences to inform practice and policy.

Our critical issues and highlights from the 2019-2020 reporting year
Our faculty's proficiencies span the gamut from the molecular to plant and livestock breeding, from farm sustainability to ecosystem modeling, and help ensure that solutions to problems are economically viable, socially acceptable, and equitable.

The critical issues addressed in our research and extension programs continue to evolve with time as new challenges, such as the COVID-19 pandemic, arise, and needs change. Below we highlight some of the noteworthy research and extension efforts from each critical issue this past year, *in addition to the projects featured in Section 5 in more detailed summaries.*

Advancing Agricultural and Food Systems through the use of state-of-the-art technology and interdisciplinary collaboration to increase agricultural resiliency and efficiency.

- Pruning apple trees represents about 20% of total preharvest production costs, and the tree-fruit industry is struggling with increasing labor costs and a limited labor pool. A Penn State research team developed the first robotic cutting mechanism—or "end-effector"—for a fully automated, computerized pruning system for modern apple orchards. This is an early step in the creation of a technology aimed at easing the challenges facing tree-fruit growers.

- More than 99% of all known Holstein artificial insemination bulls (AI) in the U.S. can be traced through their male lineage to just two bulls born in the 1950s. Because the Y chromosome is passed exclusively from sire to son, this suggests that variation is limited for much of the Y chromosome. Two additional male lineages that are separate from modern lineages before 1890 were present at the start of the AI era and had semen available from the USDA National Animal Germplasm Program. A Penn State–led team used semen from those lineages for in vitro embryo production by mating to elite modern genetic females. Genomic evaluation of the resulting sons suggested that lineages from the beginning of the AI era could be reconstituted to breed average for total economic merit in one generation when mated to elite females. Semen from the bulls is commercially available to facilitate efforts to restore lost genetic diversity.

Developing Biologically Based Materials and Products to meet the promise of sustainable clean energy, beneficial reuse of agricultural waste, and income generation through new, value-added bioproducts to support struggling economies.

- A team of agricultural and biological engineers successfully used biofilm reactors to enhance the fermentation process that creates the most potent form of vitamin K, Menaquinone-7 (MK-7). The innovative approach promises to reduce industrial-scale production costs for the supplement, which has been shown to reduce risks of cardiovascular disease, strokes, osteoporosis, and cancer. The Penn State Research Foundation is pursuing intellectual property protection for this technology.

- A team of interdisciplinary researchers used models to simulate switchgrass cultivation, biofuel production, and carbon capture and storage, tracking the carbon and ecosystem impacts. They compared the results with other ways to store carbon on land, such as growing forests or grasslands. They found that growing switchgrass, a leading candidate for next-generation biofuels, on lands transitioning away from crops or pasture has climate benefits comparable with reforestation and greater than grassland restoration. The findings offer a roadmap for how and where to pursue biofuels, and reassert the prominent role the technology can play in combating climate change.

Building Community Resilience and Capacity through integrated research and extension programming that promotes economic and social well-being by encouraging agritourism and entrepreneurship, community health, and sustainability in infrastructure, food, and energy systems.

- An analysis of hops growing in the U.S. showed that the number of hop farms in a state is related to the number of craft breweries. The study suggests that in areas where hop production is possible and not cost-prohibitive, breweries are expanding markets for farmers and providing an opportunity to diversify farm income. The university's Business, Entrepreneurship and Community Development Extension team sent out a hops producer survey to improve their outreach to this portion of the farming community.

- In cooperation with the Pennsylvania Department of Conservation and Natural Resources, a Green Industry Extension team member annually teaches an arborist short course at the State Correctional Institution–Rockview to about 15 inmates soon to be released. The course covers tree anatomy, pruning, landscaping, chainsaw safety, and arboriculture. At least seven participants are now working in arboriculture. The course is on hold because of the pandemic.

Promoting Environmental Resilience by assessing and protecting ecosystems and ecosystem services, helping agriculture meet its environmental challenges, promoting ecosystem resilience and health, and mitigation and adaptation to climate change.

- A 6-year comparison of two types of crop rotations under no-till production found that by diversifying crop rotations to create conditions that promote beneficial, predatory insects to combat pests, farmers can reduce their reliance on insecticides to control early-season crop pests, such as caterpillars, and

still produce competitive yields of corn and soybeans. Comparison was between a standard corn and soybeans rotation in which preventive insecticides were used twice annually to suppress caterpillars and other pests, and a diversified rotation of corn, soybeans, winter wheat, and cover crops that used insecticides only as needed. All of the crop Extension teams work extensively with farmers on integrated pest management.

- A Penn State–USDA study modeled and compared runoff and pollution from Spring Creek watershed in central Pennsylvania under two scenarios: using all of the best management practices (BMPs) identified for a watershed and a customized, most cost-effective set of BMPs tailored for that watershed. The team concluded that using site-specific watershed data to determine the most cost-effective agricultural best management practices—rather than requiring all the recommended practices be implemented across the entire watershed—could make staying below the Chesapeake Bay's acceptable pollution load considerably less expensive. The Field and Forage Crops Extension team works extensively with farmers on nutrient management.

Supporting Integrated Health Solutions by developing functional foods for positive health outcomes, overcoming food safety concerns, fostering human and livestock health, and fighting insect-borne diseases and parasites.

- Pulsed UV light is an emerging microbial inactivation technology that can be used in the food industry. A team of agricultural and biological engineers found a 3.18 log reduction in the number of Salmonella colonies on shelled walnuts with pulsed UV light treatment. A 3 log reduction corresponds to inactivating 99.9% of the target microorganism, with the microorganism count being reduced by a factor of 1,000. The treatment produced no significant difference in the quality and color of the treated walnuts. The team is also working on use of UV light to inactivate *Escherichia coli* and Salmonella Enteritidis in liquid egg whites. The Industrial Food Safety Extension team collaborates with industry as requested to develop and help implement new technologies for food safety.

- An international team of researchers found that perfluorooctane sulfonate (PFOS), an industrial chemical phased out since 2002, but previously used in stain- and water-repellent products and firefighting foam, alters composition and function of the gut microbiome of mice and could have implications for human health. PFOS persists in the environment and in the bodies of living organisms. The U.S. Environmental Protection Agency designated PFOS a "contaminant of emerging concern" and its production was voluntarily stopped in the U.S., but it is still detected in the blood of up to 99% of the U.S. population.

Fostering a Positive Future for Youth, Families, and Communities by providing a wide range of evidence-based programming to support healthy families, build positive youth skills, strengthen intergenerational relationships within communities, and promote farm safety.

- The Census of Fatal Occupational Injuries covers all occupational agriculture fatalities, but excludes child and non-worker bystanders and public roadway collision victims who were not working, even if a working farm machine was directly involved. A team of farm safety experts analyzed cases in this database and considered what we lose by excluding non-occupational victims of farm injuries. They argue that if injury prevention is a primary goal, we should continue to analyze data related to agricultural injury, regardless of victims' occupational status. Results from this study point to the gaps in current agricultural injury surveillance and help move the conversation toward federal policy discussions. The Farm Safety Extension team conducts extensive outreach to reduce farm-related injuries.

- Penn State's Access, Equity, and Inclusion 4-H Working Group, established in fall 2019, identified its mission/purpose as "to support the enhancement of an inclusive 4-H Youth Development program in Pennsylvania, striving to increase reach with high quality, long term relationships to connect with underrepresented audiences in all communities." The working group is aligning its work with the National 4-H Strategic Plan, 4-H Youth Development: A 2025 Vision, through which National 4-H has made a promise to America's children that by 2025, 4-H will reflect the demographics, vulnerable

populations, diverse needs, and social conditions of the country. This vision has caring adults, serving at minimum 1 in 5 youth, and the volunteers and staff reflect the diversity of the population. National 4-H has identified the following audiences that have been underrepresented within 4-H programs:

- Incarcerated youth
- Immigrant and refugee youth
- LGBTQ+ youth/community
- Youth experiencing mental health and wellbeing challenges
- Youth experiencing homelessness
- Youth in foster care
- Youth with disabilities
- Youth living in poverty
- Racial and ethnic youth
- African American youth
- Asian/Pacific Islander youth
- Latino/Hispanic youth
- Native American youth
- First-generation 4-H members

II. Merit and Scientific Peer Review Processes

The NIFA reviewer will refer to your 2020 Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Process	Updates ONLY
1. The Merit Review Process	The Merit Review Process submitted for the FY2020-2024 Plan of Work remains accurate and up-to-date.
2. The Scientific Peer Review Process	The Scientific Peer Review Process submitted for the FY2020-2024 Plan of Work remains accurate and up-to-date.

III. Stakeholder Input

The NIFA reviewer will refer to your 2020 Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Stakeholder Input Aspects	Updates ONLY
1. Actions taken to seek stakeholder input that encouraged their participation with a brief explanation	The following information is new or updated information from this reporting year (FY2020) to augment what was previously submitted and approved in the FY2020-2024 Plan of Work. The results of assessments will be incorporated into our Extension Program SharePoint site and our Extension Beyond Civil Rights One Drive folder. The former Extension Program Activity System (EPAS) is no longer utilized.
2. Methods to identify individuals and groups and brief explanation.	The Methods to Identify Individuals and Groups submitted for the FY2020-2024 Plan of Work remains accurate and up-to-date.
3. Methods for collecting stakeholder input and brief explanation.	The Methods for Collecting Stakeholder Input submitted for the FY2020-2024 Plan of Work remains accurate and up-to-date.
4. A Statement of how the input will be considered and brief explanation of what you learned from your stakeholders.	The following information is new or updated information from this reporting year (FY2020) to augment what was previously submitted and approved in the FY2020-2024 Plan of Work. • To Identify Emerging Issues: Stakeholder feedback will help to identify emerging issues, such as the effects of the COVID-19 pandemic on agricultural operations and food safety, that would benefit from extension programming and/or research. • To Determine How and Where Programs are Offered: All former considerations remain, but Extension will also take what we've learned this past year into rigorous evaluation strategies to determine the best practices and lessons learned from the pandemic to influence future face-to-face and online engagement with stakeholders.

IV. Critical Issues Table of Contents

No.	Critical Issues in order of appearance in Table V. Activities and Accomplishments
1.	Advancing Agricultural and Food Systems
2.	Developing Biologically Based Materials & Products
3.	Building Community Resilience and Capacity
4.	Promoting Environmental Resilience
5.	Supporting Integrated Health Solutions
6.	Fostering a Positive Future for Youth, Families, & Communities

V. Activities and Accomplishments

Please provide information for activities that represent the best work of your institution(s). In your outcome or impact statement, please include the following elements (in any order): 1) the issue and its significance (e.g. who cares and why); 2) a brief description of key activities undertaken to achieve the goals and objectives; 3) changes in knowledge, behavior, or condition resulting from the project or program's activities; 4) who benefited and how. Please weave supporting data into the narrative.

No.	Project or Program Title	Outcome/Impact Statement	Critical Issue Name or No.
1.	Penn State Extension poultry team helps the industry withstand COVID-19 outbreak	**Issue:** During the pandemic, large grocery store meat shelves were not fully stocked and worried consumers looked to buy food locally or raise their own. Demand at small, local meat processing businesses grew so much that they could barely keep up, and most were temporarily shut down or slowed by the need to address workers' COVID-19 infections or minimize potential exposures. **Target audience:** No part of animal agriculture or society has been immune to the effects of the pandemic on the food chain. Extension educators have been acting as farm advisers and resources for the agriculture industry and government. The owners of affected farms and processing plants benefit from their expertise in helping to keep their operations running safely, humanely, and profitably. Citizens and businesses benefit from a more stable and adaptable food supply and sustainable farm and food industry operations. **What has been done:** Before the pandemic some Pennsylvania small-scale meat processors took the Penn State Extension course "Hazard Analysis Critical Control Point for Meat and Poultry Processors" (HACCP). This allowed their shops to be	1

		inspected and certified by the USDA Food Safety and Inspection Service. This allowed one shop, for example, to quickly scale up their meat sales by 75-80% in spring 2020 to meet growing demand. The Penn State Extension poultry team helped Pennsylvania egg farms and meat processors with preharvest HACCP training; worker safety protocols; biosecurity; bird euthanasia requirements, as well as safe composting and disposal and information about USDA financial assistance with these processes; preparation of poultry houses for rehousing flocks; poultry disease awareness and management; and animal welfare. The team launched the Small Flock Program in April 2020 and offered 12 programs through September 2020 for people wanting information about small and backyard poultry flocks. More than 1,900 people viewed the program. Many people found that starting their own backyard flock gave them peace of mind in food security, but also fed their spirit and gave them something to look forward to. The team experienced a 158% increase in service in this area. **Results:** Here's just one example of a business that the Extension poultry team helped: When Empire Kosher Poultry, Inc., decided it had to close its plant in Mifflintown because workers were infected by COVID-19, the Extension poultry team was called in. The largest producer of kosher poultry in the United States, the plant had thousands of birds in the queue to be processed when it shut down. Empire wanted to minimize the impact of the closure on its business and determine what steps it could take to get back up and running again quickly. The team discussed operational biosecurity and occupational safety, and the options available to minimize the number of birds that were lost in the transaction. **External factors:** The team was forced to turn almost entirely to online educational offerings while they were simultaneously being asked to consult on an unprecedented volume and breadth of subjects and also meet a tremendous increase in demand for information about backyard flocks. **Other information:** Penn State news release. Penn State Extension helps Pennsylvania meat processors withstand COVID-19 outbreak. May 20, 2020. https://news.psu.edu/story/620717/2020/05/20/penn-state-extension-helping-pa-meat-processors-withstand-covid-19-outbreak	

2.	Penn State entomologists devise a system to control mushroom phorid flies	**Issue:** In 2012 the U.S. Environmental Protection Agency (EPA) ruled that diazinon--an insecticide that mushroom growers had used for decades to control gnat-like mushroom phorid flies (*Megaselia halterata*) could no longer be used in mushroom production because of its toxicity. That decision left mushroom farmers without an effective product for control of phorid flies. Finding a solution to the mushroom phorid fly problem was critical because Pennsylvania leads the nation in mushroom production. The state's 67 mushroom farms are mostly clustered in a few counties in the southeast. In 2020 they produced more than 500 million pounds of mushrooms. In addition to besieging area residents in ever-growing swarms, phorid fly infestations also damage mushrooms, limit crop yields, and make the job of picking mushrooms onerous. Local residents formed the Phorid Fly Action Committee, which drew sometimes more than 200 people to regular meetings with local officials and state legislators. **Target audience:** By 2020, the phorid fly invasions were affecting thousands of residents in more than 150 neighborhoods, covering more than 200 square miles of Chester and several adjoining counties, even stretching into parts of Maryland and Delaware. These residents are thrilled that this years-long problem is possibly on its way to being solved. Pennsylvania led all states in production of Agaricus (brown and white) mushrooms, with $548 million in sales, accounting for 66 percent of the total volume of U.S. sales. State, county, and local governments benefit from stability in the mushroom industry. **What has been done:** In 2016, a team of Penn State entomologists launched an intensive effort to solve the problem. The Penn State team knew that many chemical products would be effective in killing phorid fly larvae, but they cannot be used because they are not permitted by U.S. EPA for use in mushroom crops. Anything added to the compost may be taken up by the mushrooms.	1

		The team started screening biopesticide products for potential use in the compost for larval control, but they did not find anything effective. The researchers then started looking at products for control of adults, because these could be targeted away from the crop. They also studied the biology and behavior of the adults to determine if the flies were establishing populations in the residential areas. They found that populations were sustained only on the mushroom farms. **Results:** Pesticide efficacy-testing activities identified a product called EcoVia that is exempt from EPA registration, making it available for immediate use in mushroom production. The product contains botanical oils that kill adult flies when they come into contact with it. But it was the innovative application of the biopesticide at the mushroom-growing houses that made it so effective. Drawing on a technique that Penn State scientists helped develop to channel and kill malaria-carrying mosquitoes in Africa, the team worked with several mushroom farmers to implement targeted placement of electrostatic screens at key entry and exit points. EcoVia is applied to the screens and held in place by the electrostatic coating. Depending on the structure and design of the mushroom house, EcoVia is applied to other key areas, such as attics and air return vents. Over an initial 2-week period on one test farm consisting of 34 individual growing rooms, electrostatic screens placed over windows in each room killed nearly 1 million flies per room. Four weeks later the flies were nearly eliminated from the buildings, with only tens of flies killed per room. The grower was able to harvest 400,000 pounds more of mushrooms than usual from this building, due to the reduction in damage and ability to extend the duration and number of harvests from a single crop. The team intends to roll out this technology to additional mushroom growers in the state while customizing its deployment with regard to the range of different growing-room architectures and production schedules in the industry. Mushrooms are the largest cash crop in Pennsylvania, so this integrated pest management program promises to be an invaluable asset to the industry.	

		Other information: Penn State news release. Penn State entomologists devise a system to control mushroom phorid flies. Jan. 28, 2021. https://news.psu.edu/story/645709/2021/01/28/impact/penn-state-entomologists-devise-system-control-mushroom-phorid-flies Penn State researchers tackling mushroom phorid fly infestations. Penn State news release. March 19, 2018. https://news.psu.edu/story/511214/2018/03/19/research/penn-state-researchers-tackling-mushroom-phorid-fly-infestations	
3.	Penn State researchers find significant economic losses due to soybean diseases	**Issue:** Soybeans are among the most economically important crops in the U.S. Soybean was cultivated on more than 70 million acres during the 2019 growing season, with total production exceeding 97 million metric tons. But quantitative information on crop losses is scarce, difficult to obtain, seldom standardized, and a challenge to compile and compare across states, agroecosystems, and regions. The contribution of disease-associated quality loss toward the total economic loss often is ignored due to insufficient information or unavailability of a suitable loss-estimation framework. Among other factors that influence soybean growth and development, diseases are a significant challenge that can negatively affect production. One of the critical tasks of plant scientists and extension educators is to estimate how much damage each disease causes and what this means in terms of yield reduction. **Target audience:** Accurate crop loss assessment is the basis for devising appropriate management strategies to ensure farmer profitability, safeguard the nation's export soybean crop, preserve global food security, and establish research priorities. **What has been done:** To examine the long-term effects of soybean diseases on production, a Penn State-led team analyzed historical soybean-loss data gathered by soybean extension specialists and researchers and assessed the economic impacts of 23 common soybean diseases from 28 soybean-producing states in the U.S. from 1996 to 2016.	1

		Their mathematical approach helped to avoid the potential issue of having the combined losses be greater than 100% if individual losses were just added together. It also helped standardize the estimate of yield damage due to each disease considered in the study. The researchers used inflation-adjusted soybean prices when computing total economic damage by diseases. Their intent was to normalize prices so that their estimations were comparable across the time period studied. **Results:** The team found that the total estimated economic loss due to soybean diseases from 1996 to 2016 in the U.S. was $95.48 billion. The impact in the northern U.S.—$80.89 billion—was greater than losses in the southern U.S., which amounted to $14.59 billion. The findings are significant because the U.S. is the world's primary soybean producer and second-largest exporter. Over the entire period, the average annual economic loss due to soybean diseases in the U.S. reached nearly $4.55 billion, with approximately 85% of the losses occurring in the North, specifically in states such as Iowa, Illinois, and Ohio. Among southern states, Missouri, Mississippi, and Arkansas sustained the greatest losses from diseases. Across states and years, the soybean cyst nematode, charcoal rot, and seedling diseases were the most economically damaging. Soybean rust, bacterial blight, and southern blight were the least financially damaging. The research team also investigated disease-associated economic losses before and after the discovery of soybean rust, an epidemic that was reported in the contiguous U.S. in November 2004. Researchers found a significantly greater mean loss—51%—in the years following the discovery of soybean rust compared to the years before its discovery. This was probably related to intensified field scouting efforts and subsequent loss reporting. Using USDA National Agricultural Statistics Service production data, the team classified state-year combinations into one of four production zones. They found	

		that low-production zones had a lower mean economic loss due to diseases in comparison to high-production zones. High-production zones are characterized by the presence of a greater number of large farms. It's possible that resource utilization, such as timely application of foliar fungicide, could be less efficient in high-production zones, which could contribute to greater yield losses. Despite perceived challenges, the analysis of historical soybean loss data due to diseases is important to understand the economic impact of diseases, to rank diseases based on their economic importance, and to identify spatiotemporal disease occurrence and progression patterns. This information is critical for soybean pathologists and breeders, government and funding agencies, and educators to prioritize research, policy, and educational efforts in soybean disease management. **Other information:** Dissecting the economic impact of soybean diseases in the United States over two decades. *PLOS One.* April 2020. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0231141 Penn State news release. Penn State researchers find significant economic losses due to soybean diseases. April 16, 2020. https://news.psu.edu/story/615783/2020/04/16/research/penn-state-researchers-find-significant-economic-losses-due-soybean	
4.	Research helps explain source of pathogen that causes bitter rot disease in apples	**Issue:** *Colletotrichum fioriniae* causes diseases in more than 100 fruit and vegetable plants, including apple, peach, pear, and strawberry. The fungus infects the fruit under warm and wet conditions and causes brown, sunken lesions. Occasionally, orange spores are seen on the surface. The disease is of concern to the Pennsylvania apple industry as bitter rot disease. Pennsylvania produces 400 million to 500 million pounds of apples per year. The state ranks fourth in the nation for apple production, according to statistics from USDA.	1

		Target audience: Apple orchard owners, apple processors, and the public benefit from improved understanding of how to manage this common and devastating infection. The knowledge increases sustainability of these orchards and reduces the amount of fungicide applied. **What has been done:** This research was designed to determine where the spores were coming from, so that we might be able to eliminate the source and break the bitter rot disease cycle. The research, which took place in 2018 and 2019, focused on apples and involved the placement of rain-splash spore traps in orchards at Penn State's Fruit Research and Extension Center; Hollabaugh Bros., Inc., fruit and vegetable farm; and a satellite location in Arendtsville, all in Adams County. Traps also were placed in two forested areas of mostly deciduous trees near the orchards. Based on previous research showing that *Colletotrichum fioriniae* could survive on leaves, the team collected more than 1,000 leaves of apple and of 24 forest plant species. The leaves were disinfected to kill fungi on the leaf surface, frozen to kill the leaves, and incubated to allow the fungi inside of the leaves to grow out and sporulate. **Results:** Surprisingly, more spores were found in spore traps in forests than in spore traps in orchards. Subsequent testing of leaves found *Colletotrichum fioriniae* in more than 30% of leaves of forest trees and shrubs. In orchards that were managed with fungicides, up to 8% of apple leaves were infected with the fungus. In the untreated orchard, the spores were abundant, meaning they were found in 15–80% of the leaves. But the infections did not seem to be causing any leaf diseases. While unexpected, these findings did explain why growers struggle with bitter rot even when they remove all diseased fruits and twigs—the fungus was living in the leaves during the season. The fungus was present in all the tested orchards and could not be traced to infection from a nursery, which makes sense because the initial infections likely are coming from surrounding forests and fencerows.	

		Because the fungus is abundant in the forest canopy, eradication from nearby areas would be impractical. However, the spatial limitations of rain-splash dispersal mean that forests are not regular sources of fungus spread. They likely serve only as primary introduction sources during extreme rain and wind events, after which the fungus becomes established in agricultural areas. This study changes how plant pathologists think about this fungus. Although it may not supply quick fixes, it provides the basis for further research aimed at developing better management techniques, such as selecting resistant cultivars and breeding for genetic resistance. The findings make managing bitter rot in apple orchards less straightforward. In the meantime, disease-management tactics remain the same. The scientists don't believe most spores are overwintering in the leaves. Growers should continue to remove the infected fruits and twigs to help reduce disease spread season to season. **Other information:** Quantification of *Colletotrichum fioriniae* in orchards and deciduous forests indicates it is primarily a leaf endophyte. *Phytopathology.* Jan. 2021. https://apsjournals.apsnet.org/doi/10.1094/PHYTO-05-20-0157-R Penn State news release. Research helps explain source of pathogen that causes bitter rot disease. Aug. 13, 2020. https://news.psu.edu/story/628288/2020/08/13/research/research-helps-explain-source-pathogen-causes-bitter-rot-disease	
5.	Holstein steers given hormone implants grow more meat	**Issue:** Holsteins—traditionally considered dairy cattle—have become important to U.S. beef production over the last decade. In 2011, just 5% of the cattle finished in the United States were Holsteins. But in 2016, that figure had risen to 20% of finished cattle—a 400% increase in just 5 years. Hormone implants have been used in beef cattle production to improve growth performance and feed efficiency for more than 50 years, and 90% of all feedlot cattle in the U.S. receive implants. But most of the available data on implants were collected in studies conducted on beef breeds. This study focused on the use of implants to enhance Holstein beef production.	1

		Target audience: The additional meat yield from hormone-implanted Holstein steers could mean the difference between surviving and going under for a dairy farm grappling with low milk prices and declining demand. Farm families and rural communities benefit from improved farm sustainability, as do farmland preservation efforts. **What has been done:** In one of the first studies to track the effects of hormone implants in Holsteins—and in what is believed to be the only study to track hormone levels in their blood and muscles—researchers closely followed the development of 70 Holstein steers. The research sought to determine the effect of steroidal implants on growth performance, carcass characteristics, and 17 beta-estradiol concentrations in the blood and muscles of Holstein steers fed a grain-based diet. The scientists also assessed how long and how strongly the hormones influenced the growth of Holstein steers after implantation. They evaluated the so-called payout period—how long producers can expect the hormone to boost growth. **Results:** Holstein steers that get hormone implants grow faster than those that do not receive the implants. That's good news for dairy farmers struggling to keep their operations financially viable. The researchers found that Holstein steers responded to hormone implants very similarly to beef breed steers. Implanted Holstein steers had about a 10% increase in weight gain and feed intake over Holstein steers that were not implanted. Carcasses from implanted Holstein steers were about 10% heavier on average, and loin muscle area increased when compared to carcasses from nonimplanted steers. More than 80% of the animals in this trial, regardless of whether or not they received an implant, graded USDA choice or above, which means they likely became premium steaks, further increasing farmer profits. Hormone used in beef cattle production continues to be an uncomfortable topic for Americans. However, there are hormones in most foods we eat; all living things have hormones. There is even a difference in hormone levels depending on whether beef comes from a steer or a cow. Beef from females often has twice the hormone activity.	

		Foods that have more estrogenic—hormone—activity per serving than beef include beans, peas, and tofu, common protein substitutes for meat in the human diet. There is no such thing as hormone-free when it comes to the meat we eat. But that doesn't mean any of these foods are dangerous because of the hormone activity, and that includes meat. **Other information:** Effects of steroidal implants on feedlot performance, carcass characteristics, and serum and meat estradiol-17b concentrations of Holstein steers. *Translational Animal Science.* Jan. 2020. doi:10.1093/tas/txaa025 Penn State news release. Holstein steers given hormone implants grow as well as beef steers. Feb. 13, 2020. https://news.psu.edu/story/608107/2020/02/13/research/holstein-steers-given-hormone-implants-grow-well-beef-steers	
6.	Wooden pallets are more ecofriendly than plastic pallets	**Issue:** About 700 million pallets are produced and recycled each year in the United States alone. About 2 billion pallets are currently in use in the U.S., and 40 percent of all hardwood harvested in the U.S. goes into pallet production. After hearing claims about the environmental superiority of plastic pallets that he suspected were questionable, a Penn State professor led a team to investigate. With current concerns about climate change and the massive amount of resources consumed to make many millions of pallets, assessing their carbon footprint is important. **Target audience:** More than a decade ago, other studies were commissioned by the wood pallet industry and by the plastic pallet industry, and those results favored the funders. This is the first academic, peer-reviewed study related to pallets. It was conducted by leveraging funding from Penn State and is unbiased. The pallet industry, lumber companies, and environmentally concerned businesses and consumers will be interested in the results. **What has been done:** Researchers compared the long-term performance of treated wooden and plastic pallets through a detailed, cradle-to-grave life-cycle assessment, and conducted an analysis of treatments required to kill pests such as insects. They investigated and evaluated the environmental impacts of resources	2

		consumed and emissions released by wooden and plastic pallets throughout their life cycles. In the study, the environmental impacts of the pallets were compared on a one-trip basis and 100,000-trips basis, under nine impact categories chosen by researchers because of their environmental relevance. The categories included influence on ozone layer depletion, respiratory organics, aquatic ecotoxicity, terrestrial ecotoxicity, land occupation, aquatic acidification, aquatic eutrophication, global warming, and non-renewable energy. **Results:** The team found, after conducting a series of ultra-detailed comparisons, that shipping pallets made of wood are slightly more environmentally friendly and sustainable than those made of plastic. The researchers showed that on a one-trip basis, wooden pallets treated with conventional kiln heating and as-yet novel, radio-frequency heat treatment incur an overall carbon footprint that is slightly lower than plastic pallets during their life cycle. For the 100,000-trips comparison, the differences are even more significant, they reported. Wooden pallets that are heat-treated to kill pests incur a carbon footprint 20-30% lower than those treated with methyl bromide fumigation, which depletes Earth's ozone layer. Theoretical calculations of the resource consumption and emissions of radio-frequency treatment of pallets suggest that the new dielectric technology may provide a lower-carbon alternative to both conventionally treated wooden pallets or plastic pallets. Plastic pallets have a much longer life cycle than wooden pallets because plastic pallets are usually not broken or damaged and normally can travel more than 200 round trips before being taken out of service. But they are typically derived from petroleum or natural gas products, which greatly increases their carbon footprint. **Other information:** Life cycle assessment comparison of wooden and plastic pallets in the grocery industry. *Journal of Industrial Ecology.* Jan. 2020. https://onlinelibrary.wiley.com/doi/abs/10.1111/jiec.12974	

		Penn State news release: Wooden or plastic pallets: Which are more eco-friendly? Feb. 3, 2020. https://news.psu.edu/story/606589/2020/02/03/research/wooden-or-plastic-pallets-which-are-more-eco-friendly	
7.	Is India ready for alt-meat?	**Issue:** The United Nations' Intergovernmental Panel on Climate Change (IPCC) estimates that human populations have until 2030 to prevent global temperatures rising by 1.5° C, beyond which the worst impacts of climate change increase substantially. Most reliable estimates place livestock's share of global greenhouse gas emissions between 12 and 18 percent. Little is known about consumer preferences for next-generation plant-based and cell-based meat alternatives, two food technologies that offer a demand-side solution to the environmental, nutritional, and other societal concerns associated with animal-intensive agriculture. Demand-side policies aimed at promoting behavioral change are critical to mitigating the impacts of climate change. One such behavioral change being recommended by recent reports is a dietary shift toward reduced meat intake. Meat alternatives are a promising market-based solution that caters to this goal. The growing demand for animal-based proteins from developing countries such as India and China threatens global environmental resources. **Target audience:** The authors believe this study to be the first to estimate and report willingness to pay (WTP) for both plant- and cell-based meat alternatives. It is also one of the first studies to assess consumer preferences for simulated meat in the context of a developing country. The plant-based meat market in India is small, and the market for cell-based meat does not exist at all, which provides an ideal setting for stated preference research. As interest in this area of food technology grows, the results will prove beneficial for producers, entrepreneurs, marketers, and policymakers trying to encourage meat substitution in the Indian subcontinent. **What has been done:** This research estimated consumers' willingness to pay for four sources of protein (conventional meat, plant-based meat, cell-based meat, and chickpeas) in a developing country with rising demand for meat—India (Mumbai). The researchers identified four segments of the Indian market—"veggie lovers," "meat lovers," "plant-based meat enthusiasts," and "clean meat (cell-based meat) enthusiasts."	2

		Results: Aggregating across all four segments, respondents are willing to pay a premium for plant-based meat and a smaller premium for cell-based meat over the price of conventional meat. But the main findings show that these premiums strongly differ across the four consumer-class segments. The research team proposed that environmental policies targeting veggie lovers may not be effective because this group already prefers a relatively sustainable protein. The remaining three groups represent 79% of the sample. The plant-based meat enthusiasts and the clean meat enthusiasts (> 50% of the sample, combined) have a strong preference for simulated meat products over conventional meat or chickpeas. They are likely to be the first adopters of simulated meat products in India. They also prefer conventional meat to chickpeas. Enticing meat lovers to substitute meat alternatives will require pricing simulated meat considerably lower than conventional meat. Consumers perceive simulated meat products to have health, environmental, and animal welfare benefits compared to conventional meat. This suggests that the Indian market will be receptive to meat substitutes. Plant-based meat rated consistently higher than clean meat and had a higher WTP. The plant-based meat enthusiast group was the largest of the four identified segments (32% of sample). Of the two simulated meat alternatives, plant-based meat alternatives have stronger prospects in India compared to clean meat. The results offer important insights into future price points and policy options that might make these meat alternatives commercially successful, and therefore, a viable option in addressing societal concerns. **Other information:** Is India ready for alt-meat? Preferences and willingness to pay for meat alternatives. *Sustainability.* May 2020. https://www.mdpi.com/2071-1050/12/11/4377	
8.	Penn State Extension helps small businesses during the pandemic	**Issue:** When Pennsylvania shut down due to COVID-19, Penn State Extension quickly mobilized to help meet the array of small-business owner needs, especially in the food and agriculture sector. **Target audience:** Farmers and small business entrepreneurs, including sole proprietors, in Pennsylvania and beyond benefited from Extension's expertise as	3

		they dealt with not only COVID-19 restrictions but also low commodity prices and supply chain disruptions. Working to ensure the viability of the ag industry for future generations helps to keep those families and the businesses they interact with on solid financial footing and helps sustain their communities. **What has been done:** Penn State Extension's team of educators worked to assist the agriculture, food system, and small business entrepreneurs of Pennsylvania. The Business, Entrepreneurship, and Economic Development Team provided education and resources related to financial management, business planning, startup and enterprise development, COVID-19 support, technical needs, grower and entrepreneur networking, and other topics. *Resources about the Federal Paycheck Protection Program.* Extension educators developed and offered information to small business owners about the federal Paycheck Protection Program, authorized under the federal Coronavirus Aid, Relief, and Economic Security (CARES) Act, including how to apply for loan forgiveness. Nearly 2,500 businesses across at least 19 industries participated in the live or recorded webinar trainings on this program, and they applied for at least $2.3 million in loans. *Farmers Market Forum.* Farmers markets are deemed essential businesses during the pandemic. The Pennsylvania Department of Agriculture (PDA) created guidance for procedures to allow farmers markets to reopen. Extension educators created articles and webinars to share this information widely. They hosted weekly Zoom forums for market managers to learn best practices from each other and from experts. A big emphasis was on helping vendors get set up to accept online orders and payments. By fall 2020, 300 market vendors were processing online orders for pick up at farmers markets to sustain our Commonwealth's food system. Markets were averaging $18,305 per week in online orders. *Guide to the "Retail New Normal*." Extension educators provided a road map to the "retail new normal" for food and farm businesses through a webinar series of the same name. A lot of pandemic-driven trends—online sales, curbside pickup, social media marketing, buying local—are expected to continue. Extension educators helped retailers and producers figure out how to integrate these trends into a sustainable business. They offered clients webinars on topics such as	

		software skills, packaging and food safety analysis during COVID, contactless delivery options, and online sales optimization. *Help with outreach on and applications for the Fresh Food Financing Initiative.* This grant program, funded by the federal CARES Act and administered by PDA, sought to stimulate investments in low- to moderate-income communities and food retail businesses owned by underrepresented people. These communities have been historically disadvantaged and disproportionately affected by COVID-19. These funds begin to address this inequity and will improve health outcomes by increasing access to fresh food. **Results:** Extension educators assisted in the successful application of approximately $550,000 in relief funds for COVID-19 related expenses and infrastructure improvements to increase food security in USDA-designated food desert areas under the Fresh Food Financing Initiative. The Business, Entrepreneurship, and Economic Development Extension team launched 136 new webinars, 18 new videos and apps, and 141 new publications, articles, and news items in response to COVID-19 in the program year. The team's online courses had more than 18,000 sign-ups and nearly 13,000 course starts. **External factors:** The global pandemic forced the team to pivot to immediate needs of the business community and put off or alter plans for other programs. However, the expansion of virtual programming allowed Extension to expand its geographic reach and further their expertise in digital outreach modes. **Other information:** Penn State news release. Penn State Extension webinars outline process for Paycheck Protection Program. April 24, 2020. https://news.psu.edu/story/617160/2020/04/24/impact/penn-state-extension-webinars-outline-process-paycheck-protection Minority-owned businesses make groceries more accessible in Chambersburg. *Public Opinion Online,* Chambersburg. Oct. 16, 2020. https://www.publicopiniononline.com/story/news/local/2020/10/16/local-business-owners-bring-cultural-cuisine-chambersburg/3664124001/	

		Fresh food grants: Improving community's food security. *Franklin County Free Press.* Sept. 21, 2020. https://fcfreepresspa.com/improving-communitys-food-security/	
9.	For small and minority farmers, networks influence the bottom line	**Issue:** Small-scale and minority-owned farms don't always have the same access to external resources that larger farms do, so these farmers often rely more heavily on their internal or social networks for information and resource sharing. **Target audience:** Small-scale and underrepresented farmers benefit from understanding that their interactions on social networks can affect their farms' bottom line. The findings can also help farming groups and agricultural support organizations leverage networks to enhance farmers' success. The findings of the efficacy of social networks in marketing can be extended to other fields as well. **What has been done:** A Penn State-supported study looked at the social networks of small-scale and minority specialty-crop farmers in Tennessee, Maryland, and Delaware. The research was carried out in three phases: 1) identify the networks themselves in the communities; 2) identify which farmers were most central to the network; and 3) test whether being central in the network influences individual farms' economic performance. To identify farmer networks, research team members from Tennessee State University, University of Maryland-Eastern Shore, and Delaware State University worked with their respective Cooperative Extension units to identify small-scale and minority specialty-crop farmers in each of their states. The resulting group of farmers, 117 in three states, was surveyed to obtain information for the network analysis. Farmers answered questions about the nature of the relationships in their network. The researchers then analyzed each respondent's position in their respective network and other measures of connection. Using statistical techniques, they examined the effect of each of these centrality measures on farm performance. The researchers also examined the extent to which demographic and socioeconomic factors influence a farmer's position in the network.	3

		Results: Farmers who played a more prominent role in their network reported greater sales. This research shows that this networking pays off in terms of their sales. Farmers who added a single new connection to their network experienced up to a 25% increase in sales. This work shows that people who have stronger connections—at work, in society, with friends—have advantages. They may be more gregarious and more easily make contacts, and therefore also have more access to information. This translates into an advantage in terms of greater sales for a small-scale vegetable farmer. The research team, which reported their results in the *Journal of Agriculture, Food Systems, and Community Development*, also produced a training manual to help agricultural support organizations conduct their own network analyses. By identifying and characterizing farmer networks, organizations can more effectively disseminate information by targeting those farmers who have greater centrality and are more likely to share it with other farmers. An extension educator in Delaware used this manual to establish the First State African American Farmers Association. **Other information:** Small and minority farmers' knowledge and resource sharing networks, and farm sales. Findings from communities in Tennessee, Maryland, and Delaware. *Journal of Agriculture, Food Systems, and Community Development.* April 2020. https://www.foodsystemsjournal.org/index.php/fsj/article/view/804 Penn State news release. For small and minority farmers, networks influence the bottom line. April 20, 2020. https://news.psu.edu/story/615847/2020/04/20/research/small-and-minority-farmers-networks-influence-bottom-line	
10.	Utility-scale solar development in Pennsylvania and the Northeast	**Issue:** The Penn State Extension Energy team estimates that at least 5,000 Pennsylvania farmers and landowners have been approached with a solar lease/purchase option for utility-scale solar energy on their property. Fifty-two of 67 Pennsylvania counties have utility-scale projects in the queue for the region's electric grid operator. It is projected that only 10-20% of those projects will be built, but experts estimate that about $13.2 billion may be invested in utility-scale solar in Pennsylvania, with about $4 billion of that by 2030. The	3

		Commonwealth of Pennsylvania estimates that about 80,000 acres of land in the state will be occupied by solar arrays to accommodate the state's solar energy goals. **Target audience:** Extension outreach about solar energy development benefits landowners and their families and future generations in helping them understand the complex lease and related option agreements. It is helping local officials understand how other jurisdictions have handled solar regulation and development. By providing fact-based information about solar energy development, the team is assisting in a quickening energy transition in Pennsylvania and beyond, in this case based on a more rapid adoption of renewable energy resources. They are also educating other states' and countries' government officials on the lessons Pennsylvania has learned in this burgeoning field. **What has been done:** Penn State Extension staff developed a unique series of webinars, workshops, and publications, and offered individual assistance to farmers, landowners, neighbors, and local and state government officials regarding many aspects of solar development. Staff have also developed webinars on agrivoltaics—the concurrent use of land for solar energy generation and farming. They are collaborating with experts at other universities on research and outreach and answering frequent questions from farmers. Not everyone is thrilled with the idea of converting farmland to solar fields. Some people are concerned about farmland preservation and the effects on property values, tourism, wildlife, and water quality, and the extension team is talking with all concerned parties. Local governments do not generally have ordinances or policy designed to handle utility-scale solar development. Extension, working with the Penn State Dickinson School of Law, designed and delivered several workshops for local officials to understand the development and the impact of local regulations and to explore what other communities have done to address the issue. The Extension Energy team has for several years offered Immersive Energy Training, through which international government officials receive 3-5 days of training on various kinds of energy development in Pennsylvania. Solar energy has	

		been added to this training. Officials from Colombia, Argentina, South Africa, the United Kingdom, Ireland, and Australia have participated in this field and classroom learning experience, which has gone virtual with the pandemic. **Results:** The Extension Energy team offered 19 landowner leasing webinars for the public in the 2020 program year, with more than 3,600 registrants. They also offered 11 private webinars for government officials. This is very much a work in progress to provide fact-based information and help educate landowners, neighbors, and government officials and encourage reasonable land use policies and regulations. **External factors:** The pandemic forced an abrupt switch to almost entirely online education and outreach. State and national government funding and policy priorities influence the attractiveness of investment in various energy sources and therefore drive interest in educational resources. **Other information:** Penn State Extension. Renewable Energy Resources. https://extension.psu.edu/energy/renewable-and-alternative-energy/renewable-energy-resources Pennsylvania is on the cusp of a solar energy boom. Some communities want to fight it. State Impact Pennsylvania, Dec. 23, 2020. https://stateimpact.npr.org/pennsylvania/2020/12/23/pennsylvania-is-on-the-cusp-of-a-solar-energy-boom-some-communities-want-to-fight-it/	
11.	Insecticides becoming more toxic to honey bees	**Issue:** Insecticides are important for managing insects that damage crops, but they can also affect other insect species, such as bees and other pollinators, in the surrounding landscape. Populations of pollinating insects, which play a critical role in agricultural production, are declining. **Target audience:** A greater understanding of the impacts of neonicotinoid seed treatments throughout the ecosystem will enable seed companies and growers to make better decisions about which seed treatments to make available and to purchase. All of society would benefit from a more stable population of pollinators. Recent research conducted by Penn State and University of Pittsburgh scientists found that the economic value of insect pollinators totaled $34 billion in the U.S. in 2012, much higher than previously thought.	4

		What has been done: The research team integrated several public databases—including insecticide use data from the U.S. Geological Survey, toxicity data from the U.S. Environmental Protection Agency, and crop acreage data from USDA—to generate county-level annual estimates of honey bee "toxic load" for insecticides applied between 1997 and 2012. The team defined toxic load as the number of lethal doses to bees from all insecticides applied to cropland in each county. The researchers generated separate estimates for contact-based toxic loads, such as when a bee is sprayed directly, and oral-based toxic loads, such as when a bee ingests the pollen or nectar of a plant that has recently been treated. They generated a map of predicted insecticide toxic load at the county level. **Results:** During the past 20 years, insecticides applied to U.S. agricultural landscapes have become significantly more toxic to honey bees when ingested—over 120-fold in the Heartland, which USDA defines as all of Iowa, Illinois, and Indiana; most of Missouri; and part of Minnesota, Ohio, Kentucky, Nebraska, and South Dakota. The Northern Great Plains had the second highest increase at 53-fold. This region includes all of North Dakota and part of South Dakota, Nebraska, Colorado, Wyoming, Montana, and Minnesota. The team found that the pounds of insecticides applied decreased in most counties from 1997 to 2012, while contact-based bee toxic load remained relatively steady. In contrast, oral-based bee toxic load increased by ninefold, on average, across the country. This dramatic increase in oral-based toxic load is connected to a shift toward widespread use of neonicotinoid insecticides, which are unusually toxic to bees when they are ingested. Several studies have shown that these seed treatments have negligible benefits for most crops in most regions. But growers often don't have the option to purchase seeds without these treatments. This study is the first to characterize the geographic patterns of insecticide toxicity to bees and reveal specific areas of the country where mitigation and conservation efforts could be focused.	

		The researchers suggest that the common method of evaluating insecticide-use trends in terms of pounds of insecticides applied does not give an accurate picture of environmental impact. The indicator used here—bee toxic load—can be considered an alternative indicator in cases where impacts to bees and other nontarget insects are a concern. This is particularly relevant given that many states have recently developed Pollinator Protection Plans to monitor and address pollinator declines. The calculation of bee toxic load provides information about the total toxicity of insecticides applied to a landscape. It does not calculate how much of that insecticide actually comes in contact with bees, or how long the insecticide lasts before it is broken down. **Other information:** County-level analysis reveals a rapidly shifting landscape of insecticide hazard to honey bees (*Apis mellifera*) on US farmland. *Scientific Reports.* Jan. 2020. https://www.nature.com/articles/s41598-019-57225-w Penn State news release. Insecticides becoming more toxic to honey bees. Jan. 21, 2020. https://news.psu.edu/story/604682/2020/01/21/research/insecticides-becoming-more-toxic-honey-bees	
12.	Optimal dosage of a methane-inhibiting additive in dairy cow feed shown in study	**Issue:** The average dairy cow burps more than 350 pounds of methane, a potent greenhouse gas, per year. Reducing this output is important to reducing the carbon footprint of dairy and beef cattle production to help slow climate change. **Target audience:** Greenhouse gases from animal agriculture are just 5% of the total greenhouse gases produced annually in the United States, but if there is a way to reduce these emissions without affecting profitability on the farm, we should pursue it. Everyone would benefit from reduced methane emissions and the slowing of climate change, as well as improving the sustainability of dairy and beef farms. **What has been done:** A Penn State-led international team of researchers determined the optimum amount of a new methane-inhibiting supplement in dairy cattle feed.	4

		Previous studies conducted at Penn State and around the world showed the addition of 3-nitrooxypropanol—often referred to as 3-NOP—to the feed of dairy cows reduced their methane emissions by about a third. The research team has experimented with many feed additives in recent years. 3-NOP is the only substance that has worked significantly in reducing enteric methane in cattle and not had unacceptable effects on milk production or quality. **Results:** This follow-up research showed that the optimum dose of the white, granular compound made by Dutch health and nutrition giant DSM is 150 mg/kg of dry feed—about a tablespoon in every 250 pounds of feed. Widespread use of the compound could be an affordable climate change-battling strategy, if farmers embrace it. The decrease in methane emission yield (methane per unit of dry feed intake) in the study ranged from 16 to 36%, and emission intensity (methane per unit of milk) reduction ranged from 25 to 45%. 3-NOP did not affect dry matter intake and milk yield of the cows. As a bonus to the methane mitigation, milk fat concentration and yield increased. DSM, which has a patent on 3-NOP, has already applied to European regulators for authorization to sell the compound as a feed additive for cattle. The company hopes to launch the product in the European Union soon, followed by registrations in other regions such as Brazil, Australia, New Zealand, and Canada. U.S. approval, if it is granted, will come slower because 3-NOP is considered a drug here and will be regulated by the U.S. Food and Drug Administration. **External factors:** Pennsylvania and Mid-Atlantic dairy producers faced drought, milk price instability, and supply chain disruptions in this program year, which continue to strain farm profitability and sustainability. Any methane-reducing additive must be cost-effective and not reduce milk yield if producers are to use it. **Other information:** Dose-response effect of 3-nitrooxypropanol on enteric methane emissions in dairy cows. *Journal of Dairy Science*. April 2020. https://www.journalofdairyscience.org/article/S0022-0302(20)30258-7/fulltext	

		Penn State news release. Correct dosage of methane-inhibiting additive in dairy cow feed shown in study. July 21, 2020. https://news.psu.edu/story/626404/2020/07/21/research/correct-dosage-methane-inhibiting-additive-dairy-cow-feed-shown	
13.	Multipronged strategy is tackling invasive spotted lanternfly	**Issue:** Spotted lanternfly (SLF) is an invasive insect from Asia that has spread throughout Pennsylvania since its discovery in Berks County in 2014. SLF feeds on the sap of many different plants, including grapevines, maples, black walnut, and other important plants in PA. SLF is also found in New Jersey, Maryland, Delaware, Virginia, and West Virginia. **Target audience:** Growers of tree fruit and grapes, hardwood timber, nursery trees, and Christmas trees are eager for scientifically based management recommendations for SLF to slow or stop its destructive spread. Many Mid-Atlantic-area residents want to do their part in helping to track and trap SLF as it expands its territory and follow Penn State Extension recommendations on identifying and destroying these insects and their eggs, and building and deploying traps for SLF. **What has been done:** This pest has inspired groundbreaking collaboration among Penn State researchers, extension educators, and communications staff; the Pennsylvania Department of Agriculture (PDA); and USDA. Weekly meetings allow the researchers to stay informed on the latest needs of and share progress with growers, and allow the team to more quickly develop useful outreach products. The research team is working on the multiyear process of determining the economic threshold of infestation in various crops beyond which control measures are cost-effective, as well as on assessment of treatment efficacy. PDA is managing SLF populations by using the insect's preferred host, the invasive *Ailanthus altissima,* or tree of heaven, as a trap tree. This technique involves the removal of about 90% of the ailanthus and treating those that remain with a systemic insecticide. This forces the lanternfly to feed on the remaining tree of heaven and ingest insecticide, which has proven to be a very effective form of control.	4

		Results: If not contained, SLF could potentially drain Pennsylvania's economy of at least $324 million annually and cause the loss of 2,800 jobs, according to a new study carried out by economists at Penn State. Under a worst-case scenario, in which damage reaches the maximum projected by crop-production and forestry experts, these losses could increase to $554 million annually and almost 5,000 jobs. The report places current economic damages due to the pest at $50.1 million per year with a loss of 484 jobs in the southeastern part of the state, primarily to nursery operators, fruit growers, vineyards, and Christmas tree growers. The findings demonstrate that the vigorous response by PDA, USDA, Penn State, and industry stakeholders to limit the spread of SLF is clearly warranted. Our economy depends on it. Penn State provides most of the training that is required for businesses operating in the SLF quarantine zone. Penn State Extension staffs a call center with a manager and about eight employees in the summer and fall to meet the demand for education and outreach on SLF in Pennsylvania and neighboring states. The call center fielded nearly 20,000 calls each year in 2019 and 2020. **External factors:** The pressing nature of SLF impact and spread has required a shift away from focus on other invasive insects. COVID-19 necessitated a rapid pivot almost exclusively to online learning. **Other information:** Penn State Extension. Spotted lanternfly. https://extension.psu.edu/spotted-lanternfly Penn State news release. Tracking spread, testing traps are focus of spotted lanternfly study in Altoona. May 10, 2020. https://news.psu.edu/story/619421/2020/05/10/impact/tracking-spread-testing-traps-are-focus-spotted-lanternfly-study	

		Penn State news release. Scientists examine potential economic impact of spotted lanternfly in Pa. Jan. 15, 2020. https://news.psu.edu/story/604149/2020/01/15/research/scientists-examine-potential-economic-impact-spotted-lanternfly-pa	
14.	Study finds that malaria risk is highest in early evening	**Issue:** Wide-scale use of insecticide-treated bed nets has led to substantial declines in global incidences of malaria in recent years. But there is concern that malaria-carrying mosquitoes may be changing their behavior to avoid these bed nets. **Target audience:** The World Health Organization estimates that there were 229 million cases of malaria in 2019, and 409,000 people died from it. The population most vulnerable to malaria is children under 5 years old. Africa had 94% of the world's malaria cases. Finding effective and efficient ways to address this global health crisis will vastly improve and extend the lives of hundreds of millions of people. **What has been done:** An international team of researchers conducted a series of laboratory studies to examine whether timing of feeding affects a mosquito's ability to become infectious with the malaria parasite. They presented the two most important malaria mosquitoes—*Anopheles stephensi* and *Anopheles gambiae*—with infected blood meals at different times of day and under different temperature conditions and monitored them to determine their "vector competence"—the ability to successfully acquire malaria parasites and become infectious. **Results:** The study showed that mosquitoes are more likely to become infected with malaria if they feed in the evening, than at midnight or in the morning. The researchers found that time of day of feeding itself did not affect vector competence when the temperature was maintained at a constant 80°F. However, when mosquitoes were maintained under conditions representing more realistic temperature variation—ranging a few degrees above and below 80°F—there was significant variation in vector competence, with approximately 88% of evening biters, 65% of midnight biters, and 13% of morning biters testing positive for parasites in *Anopheles stephensi* mosquitoes. For *Anopheles gambiae,* 55% of evening biters, 26% of midnight biters, and 0.8 % of morning biters were positive for parasites.	5

		Warm temperatures can inhibit parasite establishment, so the longer the time before mosquitoes are exposed to warm daytime temperatures, the better the chances that the mosquito becomes infected. Mosquitoes feeding in the morning have only 4 hours before temperatures become too hot for the parasite to be transmitted, while those that feed in the evening have 16 hours of cooler temperatures. Many studies have investigated malaria infection in mosquitoes in lab settings, but this work has tended to ignore the possible influence of environmental factors such as time of day and temperature variation. When this ecological complexity is added, plus or minus six hours in the time of feeding can transform a mosquito from being extremely susceptible to infection by malaria to becoming almost completely resistant. This variation in transmission potential has important implications for so-called "behavioral resistance," in which mosquitoes shift biting behavior toward the evening or morning to avoid contacting hosts protected under insecticide-treated bed nets. In particular, shifts to evening biting might have enormous implications for public health because not only are people not protected by bed nets at this time of day, but the mosquitoes have a higher chance of becoming infected and ultimately infectious. The researchers created a mathematical model to explore the potential public health implications of a change in mosquito infectivity driven by the timing of mosquito bites. The model results support their laboratory findings. Key next steps are to extend the work to field systems to evaluate the robustness of the findings in the real world. **Other information:** The influence of feeding behaviour and temperature on the capacity of mosquitoes to transmit malaria. *Nature Ecology & Evolution*. May 2020. https://www.nature.com/articles/s41559-020-1182-x Penn State news release. Malaria risk is highest in early evening, study finds. May 4, 2020. https://news.psu.edu/story/617895/2020/05/04/research/malaria-risk-highest-early-evening-study-finds	

15.	Bushmeat consumption may lead to serious bacterial infections	**Issue:** What is the risk of contracting potentially life-threatening bacterial diseases from bushmeat consumption? Many people in Sub-Saharan Africa regularly consume bushmeat—meat derived from wildlife—up to two to five times per week, which means that millions of people could be exposing themselves to these dangerous pathogens. And the number is growing. Bushmeat consumption and trade have been increasing because of growing food insecurity, low cost compared to other meat products, and perceived medicinal value. The problem is not confined to Africa. Bushmeat is smuggled illegally into the U.S. and Western Europe on a daily basis. Charles de Gaulle Airport in France intercepts five tons per week. This practice puts even more people at risk for contracting dangerous bacterial diseases. **Target audience:** As the COVID-19 pandemic has shown us, human health is intertwined with that of other people and animals around the world. All people and nations will benefit from greater knowledge about potential disease threats from bushmeat and the development of rapid diagnosis capabilities and plans to help curb outbreaks. **What has been done:** An international team of researchers analyzed samples of bushmeat in the Western Serengeti in Tanzania and identified several groups of bacteria, many of which contain the species that cause diseases such as anthrax, brucellosis, and Q fever. To quantify the risk associated with eating and handling bushmeat, the researchers first needed to identify the bacteria present in the meat. They obtained more than 5,000 fresh and processed bushmeat tissue samples from the predominant large herbivores—including buffalo, zebra, and giraffe—of the Serengeti National Park and surrounding areas. They collected these samples within three ecologically distinct regions, called Bunda, Serengeti, and Tarime, within the Serengeti ecosystem. Microbial and health risks associated with bushmeat samples were assessed using powerful molecular diagnostic tests to identify signatures of especially dangerous pathogens, and a subset of the samples was characterized by DNA sequencing approaches to define the microbiomes—all of the microorganisms—present in bushmeat. **Results:** The team found 27 different groups—called phyla—of bacteria in the samples, with Firmicutes, Proteobacteria, Cyanobacteria, and Bacteroidetes being	5

		the most abundant. All of these groups contain pathogenic species. Within those phyla the researchers detected DNA signatures of bacteria within the genera *Bacillus*, *Brucella*, and *Coxiella*, which contain the species that cause anthrax, brucellosis, and Q fever, respectively. These diseases can be deadly if left untreated. The researchers also found a particularly high prevalence of bacteria in the genus *Clostridium*, whose species cause diseases such as botulism and tetanus. The microbiomes of wildebeest collected during the dry season comprised more than 78% Clostridial species. Understanding which bacteria are present in bushmeat is necessary to establishing a plan to help curb outbreaks of these dangerous diseases. These data suggest the presence of certain disease-causing species, and the team's objective now is to use species-level analyses to fine-tune the focus on specific pathogens and accurately assess and mitigate the associated risk of disease outbreaks. Ultimately, the goal is also to help build capabilities for rapid diagnosis and risk mitigation in the countries of origin to address these risks before they become a problem globally. **Other information:** Microbial diversity in bushmeat samples recovered from the Serengeti ecosystem in Tanzania. *Scientific Reports.* Dec. 2019. https://www.nature.com/articles/s41598-019-53969-7 Penn State news release. Bushmeat may breed deadly bacteria. Dec. 2, 2019. https://news.psu.edu/story/600182/2019/12/02/research/bushmeat-may-breed-deadly-bacteria	
16.	Working toward identifying new microbial water quality indicators for food safety	**Issue:** In 2015, U.S. agriculture used more than 118 million gallons of water per day for irrigation, with more than half of all withdrawals originating from surface water sources. Surface water used for produce growing is a potential source of preharvest contamination with foodborne pathogens. Decisions on how to mitigate food safety risks associated with preharvest water use currently rely on generic *Escherichia coli*-based water quality tests, although multiple studies have suggested that *E. coli* levels are not a suitable indicator of the food safety risks under all relevant environmental conditions. Improved understanding of spatial and temporal variability in surface water microbiota composition is needed to	5

		enable identification of alternative or supplementary indicators that co-occur with pathogens. **Target audience:** Recent foodborne outbreaks associated with fresh produce (e.g., romaine lettuce) have raised concern among consumers about the safety of our fresh food supply. Growers have a responsibility to minimize the risk of microbial contamination on the farm. They will benefit from improved methods of testing the safety of irrigation water by reducing the incidences of foodborne illness, as will consumers. **What has been done:** This research aimed to characterize the composition of bacterial and fungal communities in the sediment and water fractions of 68 agricultural water samples collected from six New York streams. The project team investigated potential associations between the composition of microbial communities, environmental factors, and *Salmonella* and/or *Listeria monocytogenes* isolation. **Results:** This study provides baseline data characterizing bacterial and fungal microbial communities in New York agricultural water and their relationship with two foodborne pathogens. The study found significantly different composition of fungal and bacterial communities among sampled streams and among water fractions of collected samples. This indicates that geography and the amount of sediment in a collected water sample may affect its microbial composition, which was further supported by identified associations between the flow rate, turbidity, pH and conductivity, and microbial community composition. The analysis identified specific microbial families that were weakly indicative of the presence of *Salmonella* or *Listeria monocytogenes*, but further studies on whole water samples from additional streams are needed to assess whether identified families may be used as indicators of pathogen presence. **Other information:** The composition of microbial communities in six streams, and its association with environmental conditions, and foodborne pathogen isolation. *Frontiers in Microbiology.* July 2020. https://www.frontiersin.org/articles/10.3389/fmicb.2020.01757/full	

17.	Detection and removal of biologically active organic micropollutants from hospital wastewater	**Issue:** The presence of contaminants of emerging concern (CECs), such as antibiotics, antimicrobial disinfectants, nonprescription drugs, personal care products, pharmaceuticals, and steroids, in water resources can affect aquatic and human health. Although each CEC is typically detected at low concentrations (ng/L to µg/L), they may have a large impact on human and aquatic health due to their high biological potency, as well as the additive effects of compounds acting through the same biological pathway. Therefore, effective removal of CECs from wastewater is essential for protecting the health and safety of water resources. A large portion of the CECs entering regional wastewater treatment plants originates from hospitals. **Target audience:** Point-of-entry treatment of hospital wastewater to remove CECs will provide multiple benefits to society and the environment. Endocrine disrupting compounds mimic or interfere with the body's hormones, and many are slow to break down in the environment. Exposure to even low doses of endocrine disruptors may be unsafe. **What has been done:** A study involving researchers across Penn State involved exploratory analytical work to characterize two hospital wastewaters and to evaluate treatment of CECs at hospitals before dilution with domestic wastewater. A 24-hour batch reaction with biogenic manganese oxides coated onto coir (coconut) fiber was used to treat the wastewaters. Organic contaminants in the wastewaters were concentrated by extraction and analyzed by gas chromatography/mass spectrometry or ultrahigh performance liquid chromatography/mass spectrometry. **Results:** Fifty-two organic contaminants were detected in hospital wastewaters. Twenty-nine were removed by >90% and six were degraded by <50% after treatment. Control experiments revealed that sorption to coir fiber and oxidation by manganese oxides were the primary contaminant removal mechanisms. The extracts were used to evaluate potential human toxicity of the hospital wastewaters before and after treatment. Twenty-eight human cell-based bioreceptor assays were used to screen the hospital wastewaters. Secondary tests were run to quantify toxicity equivalents to activated receptors.	5

		The wastewaters initially contained organic micropollutants that strongly activated the androgen receptor, estrogen receptor β, and the mineralocorticoid receptor (which is essential for blood pressure regulation), but no bioactive compounds were detected after reaction with manganese oxides on coir fiber. Point-of-entry treatment of hospital wastewater should reduce bioactive compounds from entering the environment. **Other information:** Detection and removal of biologically active organic micropollutants from hospital wastewater. *Science of the Total Environment.* Jan. 2020. https://doi.org/10.1016/j.scitotenv.2019.134469	
18.	Stunted from the start: Early life weather conditions and child undernutrition in Ethiopia	**Issue:** Stunting, or low height for age, is the most prevalent form of undernutrition globally, affecting nearly one in four children under age five. Rates of stunting have declined worldwide over the past several decades, yet the prevalence remains high in Sub-Saharan Africa, where nearly 34% of children under five are stunted. In response to slow progress on improving nutrition in many world regions, the United Nations has focused a Sustainable Development Goal on ending all forms of malnutrition worldwide by 2030. Yet, through direct and indirect effects on health and livelihoods, climate change has the potential to undermine future reductions in stunting and other forms of malnutrition. The Intergovernmental Panel on Climate Change predicts with high confidence that future climate change in the region will exacerbate existing stresses on water resources, reduce crop yields, and increase malnutrition, particularly among children. **Target audience:** International governments, nongovernmental organizations, and citizens need to understand the potential consequences of climate change and undernutrition for all people so we can begin to address the dual problems. **What has been done:** A Penn State-led team of researchers examined the relationship between weather conditions and child nutrition in Ethiopia. They linked data from four rounds of the Ethiopia Demographic and Health Survey to high-resolution climate data to measure exposure to rainfall and temperature in utero and during early life. The scientists then estimated a set of multivariate regression models to understand how weather conditions affect child stunting, an indicator of sustained early life undernutrition.	5

		Results: The team found that greater rainfall during the rainy seasons in early life is associated with greater height for age. Higher temperatures in utero, particularly during the first and third trimesters, and more rainfall during the third trimester, are positively associated with severe stunting, though stunting decreases with temperature in early life. The research found potential evidence for a number of pathways underlying the weather–child nutrition relationship, including agricultural livelihoods, heat stress, infectious disease transmission, and women's time use during pregnancy. These findings illuminate the complex pathways through which climate change may influence child health and should motivate additional research focused on identifying the causal mechanisms underlying these links. **Other information:** Stunted from the start: Early life weather conditions and child undernutrition in Ethiopia. *Social Science & Medicine.* Sept. 2020. https://www.sciencedirect.com/science/article/abs/pii/S0277953620304536	
19.	4-H, Norris Square Community Alliance promote food security in Philadelphia	**Issue:** 4-H educators in Philadelphia saw that racial justice protests in summer 2020, as well as COVID-19 restrictions, had severely disrupted 4-H youths' access to food in the Kensington neighborhood of Philadelphia. People were afraid to leave their homes, and school district food and supplies sites were temporarily halted. **Target audience:** The families helped benefited from the food, educational enrichment materials for their children, and knowing that people cared about them. They and the neighborhood benefited from the easing of anxieties about how to access food aid. The neighborhood and the city were strengthened by the more robust collaboration between 4-H and the Norris Square Community Alliance and by the engagement of other community partners. 4-H staff and youth grew in their empathy for and understanding of the challenges facing the community. **What has been done:** 4-H educator Lauren Perez met with a representative from the Norris Square Community Alliance, with which 4-H has partnered through the Well-Connected Communities program, a collaboration among Penn State Extension, the National 4-H Council, and the Robert Wood Johnson Foundation. Well-Connected Communities is designed to support coalition-building in Norris Square to help set a direction for positive change around health challenges in this community.	6

		Perez explained the situation in Philadelphia to her fellow educators. She showed them pictures and told them the backstory. Within 3 days the educators had personally raised money, shopped, prepared food, and delivered it to Perez's house. Donations came from staff members, business acquaintances, and family. **Results:** Thanks to her colleagues' aid, Perez visited thirty 4-H families on June 5, bringing learning enrichment materials, bags of food, and "Messages of Hope"—letters written by other 4-H youth across the commonwealth. While Perez continued delivering food to families every Friday for a few weeks, 4-H and the Norris Square Community Alliance began to deepen their collaboration. Together, they created a plan to feed all the youth who were going to receive food through the Norris Square Community Alliance's summer programming, a group that included the 4-H members with whom Perez works. 4-H staff worked alongside the Norris Square Community Alliance to address issues related to food preparation, social distancing, and COVID-19. But they wanted to scale up the number of people fed and the longevity of the help. After Gov. Tom Wolf moved Philadelphia County into the "green" phase, 4-H helped the Norris Square Community Alliance switch to an on-site food delivery program, feeding youth in an alliance building while adhering to social distancing guidelines. The organizations also offered socially distant, in-person programs focused on mental health and indoor gardening. These programs switched to a virtual format following an order from city government, but the Norris Square Community Alliance continued to feed youths on-site with guidance and funding from 4-H. This effort has grown into something larger. 4-H staff are working with the community to show them how they can organize and meet their own needs, to set an example that the community can follow. The organizations have effectively bridged the gap between them, and it has led to much greater success. **External factors:** The 4-H Positive Youth Development extension team's work was shaped by the COVID-19 pandemic and its effects on vulnerable populations. In addition, the summer's social tension, which developed after the death of George Floyd in Minneapolis, also affected the team's work.	

		Other information: Penn State news release. 4-H, Norris Square Community Alliance promote food security in Philadelphia. Aug. 4, 2020. https://news.psu.edu/story/627534/2020/08/04/impact/4-h-norris-square-community-alliance-promote-food-security	
20.	Pandemic germinates Master Gardener support for nonprofits, health care workers	**Issue:** When the COVID-19 pandemic caused Penn State Master Gardeners across Pennsylvania to cancel annual plant-sale fundraisers and other gardening events this spring, they were left with thousands of vegetable and ornamental plants that needed homes. At the same time, health care workers were putting in long hours swathed in protective gear, caring for the sick, while trying to remain safe from COVID-19, and families around the state were suffering food insecurity from jobs lost or put on hold. **Target audience:** Health care workers benefited from some greenery in their lives and felt appreciated and cared for. Hungry and underserved families and school children felt reassured by having access to local produce and gained knowledge of gardening. Master Gardeners themselves benefited from the satisfaction of giving back. **What has been done:** Master Gardeners made their local communities the beneficiaries of the glut of unsold plants, donating them to various nonprofit groups, school programs, and other organizations. The state Master Gardener program also made the spring a little brighter for frontline health care workers by launching a campaign to raise funds to provide plants to staff helping to fight COVID-19 at three Penn State Health facilities. **Results:** With the plant sales cancelled, Master Gardeners across the state reached out to local nonprofit organizations to donate the plants that would have been sold at their fundraisers. In total, 19,243 vegetables, herbs, perennials, and annuals; 1,000 pounds of seed potatoes; 5,489 seed packets; and 917 hanging baskets were donated to food pantries, community gardens, churches, hospitals, and senior living communities. In Delaware County, Master Gardeners donated almost 1,000 vegetable plants—including cabbage, kale, collards, broccoli, swiss chard, and lettuce—to the Chester Eastside Food Pantry and the Chester Eastside After School Program.	6

		Staff of the after-school program planted the vegetables in raised garden beds in its community garden and planned to hold a virtual gardening class with the children. Master Gardeners in Philadelphia County donated 2,000 vegetables and herbs propagated for their Garden Day and Plant Sale to eight community gardens across Philadelphia. Statewide, Master Gardeners donated 17,388 pounds of produce to underserved communities and people experiencing food insecurity. Master Gardeners and community members raised $7,600, which was used to purchase 800 colorful hanging baskets that were distributed as a thank you to dedicated health care workers. These purchases supported green-industry businesses that had been affected economically by the pandemic. Master Gardeners were in great demand in 2020 as interest in gardening and home food preservation exploded. They conducted a 10-week Victory Garden Reinvented webinar series, which reached 10,700 people in 44 states and 7 Canadian provinces. Master Health and Wellness volunteers and other volunteers of the Extension Health and Wellness team used produce from Master Gardeners in virtual cooking and nutrition classes for resource-stressed families. **External factors:** Master Gardeners are also playing a critical role in the fight against the invasive spotted lanternfly. They help disseminate reliable and current information about the pest and its management. **Other information:** Penn State news release. Pandemic germinates Master Gardener support for nonprofits, health care workers. June 11, 2020. https://news.psu.edu/story/623032/2020/06/11/impact/pandemic-germinates-master-gardener-support-nonprofits-health-care Penn State news release. Penn State Master Gardeners spearhead effort to support health care workers. April 9, 2020. https://agsci.psu.edu/news/penn-state-master-gardeners-spearhead-effort-to-support-health-care-workers	