Shortening the Distance Between Discovery and Impact

Penn State AgScience Research

PennState
College of Agricultural Sciences

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Shortening the distance between **discovery and impact**.

Researchers in the College of Agricultural Sciences are addressing some of the **most challenging, critical issues** facing people in Pennsylvania, the nation, and the world. Their solutions are driven by a fundamental motivation to improve the health of humans, plants, and animals as well as ensure food security, protect the environment, strengthen our communities, and more.

The following highlights of research activity from the past year demonstrate how our researchers have **embraced an interdisciplinary approach** in order to address these challenges. Teams formed across scientific disciplines within the college and beyond are arriving at **novel, real-world solutions** that have positive impacts on society.

Each highlighted project reveals the significance of the researchers' discoveries and the continued need to fund further advancements. The range of promising directions and solutions presented here exhibits a **drive to leverage existing capacity and support** in order to **share applicable results** and continue to **propel research inquiries** into the next phase of discovery.

The following stories of impact are organized into six broad themes. Each captures one or more critical issues, demonstrating not only the depth and significance of the impact but also how research inquiry can approach the same objective from different angles.

Climate-smart Agricultural Systems that can adapt to a changing climate and perform responsibly

- Sustainably increasing productivity and efficiency
- Using natural defenses to improve resilience

Nutritional and Food Security at all scales from microbiome to food supply chain

- Enhancing the capacity of local and regional food systems
- Integrating modeling, data science, and visualization

Biodiversity that promotes mutually beneficial interactions among all living organisms on Earth

- Detecting and rapidly responding to biological invasions
- Managing pests with effective and low-risk strategies

Integrated Health at all levels from soil health to the dynamics of human and animal diseases

- Mitigating spread of vectorborne pathogens
- Protecting against infections and decreasing disease incidence

Human and Community Dynamics that can enhance the economic prosperity of people

- Enhancing rural communities facing socioeconomic shifts

Landscape-level Analyses that investigate complex scenarios and model holistic solutions

- Restoring and maintaining healthy, resilient ecosystems
- Enhancing responsible stewardship of watersheds

Organic soybean producers can be **both ecofriendly and competitive** using little or no tillage.

JOHN WALLACE/PENN STATE

Problem: **Can U.S. organic soybean producers achieve yields at competitive costs in a global market?**

- More than 70 percent of the organic soybeans fed to organically produced poultry in the United States is imported.
- Demand for domestic organic soybeans is high, but the conventional organic practice of tillage to control weed pressures comes with significant input costs of fuel and labor.

Findings: Researchers found that organic soybean producers using no-till and reduced-tillage production methods that incorporated cover crops can achieve similar yields at competitive costs compared to tillage-based production.

- Reduced-tillage resulted in 50 percent less soil disturbance.
- Damage from insect pests was low and did not differ between soybean production strategies.

Impact: This research provides tested alternatives for organic growers to increase the sustainable domestic production of organic soybeans. These methods:

- Decrease labor and fuel costs while contributing substantial gains in water quality and soil conservation
- Provide organic producers with critical data on the economic and agronomic tradeoffs associated with alternative strategies to increase their competitiveness in the global marketplace

Team: *John Wallace, Mary Barbercheck, Rebecca Champagne, Barbara Baraibar*

Competitive Funding: *USDA National Institute of Food and Agriculture (NIFA) (Organic Transitions Program), Organic Farming Research Foundation*

Federal and State Appropriations: *USDA NIFA Hatch Projects PEN04600 and PEN04606, Accession #1009362 and #1009990*

BIGSTOCK

Team: *Alex Hristov, Troy Ott, Audino Melgar, M. T. Harper, J. Oh, F. Giallongo, M. E. Young, Stephane Duval, C. F. A. Lage, K. Nedelkov, S. E. Räisänen, H. Stefenoni, X. Chen*

Partners: *DSM Nutritional Products*

Competitive Funding: *DSM Nutritional Products*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04664, Accession #1017181*

Finding safe, affordable, and beneficial ways to **reduce the carbon footprint** of producing milk.

Problem: **Can greenhouse emissions from animal agriculture be reduced without compromising productivity?**

- Methane's atmospheric warming potential is as much as 28–36 times higher than that of carbon dioxide over 100 years.
- The average dairy cow belches 350 pounds of methane each year as a natural byproduct of its digestion, accounting for approximately 2.7 percent of total U.S. greenhouse gas emissions.

Findings: Animal scientists studied how 3-nitrooxypropanol (3-NOP), a compound that inhibits the synthesis of methane in a cow's rumen, affected the cow's enteric methane emissions as well as milk production and quality.

- Supplemented feed decreased the cow's methane emissions by about 29 percent without affecting the sensory qualities of the milk and also increased the milk fat percent and the feed efficiency per unit of milk yield.

Impact: The use of 3-NOP to supplement cattle feed provides a safe and economical way for farmers to affordably reduce the carbon footprint of cattle production and benefit from increased feed efficiency.

- Cows quickly metabolize the small synthetic molecule, which falls apart into naturally occurring compounds present in the rumen.
- The study is a critical step in the approval process for use of 3-NOP as a methane mitigant in ruminant production.

A common soil fungus can help corn growers **control insect pests naturally**.

BIGSTOCK

Problem: **How can we reduce the risk for growers transitioning to organic production?**

- The United States is the largest producer and exporter of corn in the world, but nearly half of its organic corn supply is imported.
- Risks posed in managing insects and weeds without conventional pesticides often deter producers from transitioning their fields to organic corn production.

Findings: An interdisciplinary team inoculated seeds of corn with spores of the soil fungus *Metarhizium robertsii* to study how natural processes already occurring in the plant's roots and soil impact pest pressures and plant growth.

- Colonized plants grew taller and produced more aboveground biomass compared to control plants.
- The beneficial fungus also boosted the expression of plant defense genes.

Impact: This research demonstrates that corn growers, especially organic corn growers, can benefit from managing their fields to promote this naturally occurring fungus. Their continued research could help to develop new seed treatments that would provide for organic farmers:

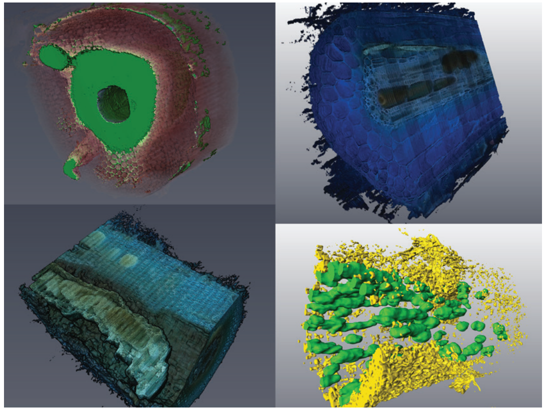
- Safe, cost-effective, and ecofriendly methods for leveraging a plant's natural defenses to cope with stresses
- Practices that can foster symbiotic relationships with microbes already present in the soil

Team: *Mary Barbercheck, Imtiaz Ahmad, María del Mar Jiménez-Gasco, Dawn Luthe, Samina Shakeeld*

Competitive Funding: *USDA NIFA (Organic Transitions Program), Organic Farming Research Foundation*

Federal and State Appropriations: *USDA NIFA Hatch Projects PEN04606 and PEN04676, Accession #1009990 and #1017795*

Novel use of laser technology paves the way for future precision breeding.



CHRISTOPHER STROCK/PENN STATE

Team: *Jonathan Lynch, Christopher Strock, Kathleen Brown, Hannah Schneider, Tania Galindo-Castañeda, Xiangrong Guo, Bart Van Gansbeke, Diane Mather, Mitchell Roth, Martin Chilvers*

Partners: *University of Adelaide, Australia; Michigan State University*

Competitive Funding: *Fulbright Teachers for Global Classrooms, USDA North Central Region Sustainable Agriculture Research and Education (SARE), U.S. Agency for International Development (USAID), U.S. Department of Energy*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04582, Accession #1005492*

Problem: **Can we breed more productive crops that are resilient to climate variability?**

» Extreme precipitation events, prolonged droughts, temperature extremes, and elevated pressures from pests and diseases prompt the need for the breeding of more resilient and productive crops.

Findings: A team of plant scientists has developed a novel use of its laser ablation tomography (LAT) system, a technology invented at Penn State, to visualize the anatomy of roots and see how soil organisms, such as fungi, nematodes, and insects, interact with the roots of different crop species.

» A pulsing ultraviolet laser excites various tissues affected by soil organisms. The light spectra given off by different cells allow the scientists to capture detailed images of microscopic slices that can be reconstructed in three dimensions.

Impact: This novel technology provides scientists with a unique perspective of the interactions in order to develop crops that more effectively grow under limited water and nutrient availability.

» Using LAT, a researcher can process many root samples in a short period of time, addressing a major limitation for researchers conducting genetic studies and running breeding programs.

» The technique allows researchers to conduct large, quantitative screenings to characterize genetic control of root anatomy and interactions with soil organisms.

Analysis helps fine-tune food, agricultural, and nutritional programs to **reduce food waste**.

ADOBE STOCK

Problem: **How can we reduce the amount of food that is discarded in the United States?**

- Up to 40 percent of the total food supply in the nation goes uneaten, but food waste levels for individual households has been nearly impossible to estimate.

Findings: Penn State researchers developed a novel approach to estimate household-level food waste by comparing household food acquisition data with food energy needed to maintain body weights. Food acquired in excess of metabolic energy needs represented waste.

- The study identified household characteristics associated with different levels of food waste.
- They found that American households waste, on average, almost a third of the food they acquire, or about $1,866 annually, with an estimated aggregate value of $240 billion annually.

Impact: The findings from this research could help inform revisions in food, agricultural, and nutritional programs, with an eye toward reducing the amount of food discarded by Americans and furthering research on individual household food waste.

- Beyond economic and nutritional implications, reducing food waste can help decrease the significant greenhouse gas emissions it causes.

Team: *Edward Jaenicke, Yang Yu*

Competitive Funding: *USDA NIFA (Agriculture and Food Research Initiative), USDA Economic Research Service*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04709, Accession #1019915*

Team: *Leland Glenna, Yetkin Borlu*

Partner: *Social and Economic Sciences Research Center, Washington State University*

Competitive Funding: *USDA NIFA (Specialty Crop Research Initiative)*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04612, Accession #1010877*

Understanding factors influencing perceptions of climate change helps to **advance productive dialogues.**

Problem: **How can climate change mitigation become a priority for U.S. agriculture producers?**

- Over the past four decades, agriculture has increasingly been affected by weather disruptions linked to a changing climate.

Findings: Social scientists examined farmers' perceptions of resource availability and climate change over four years using surveys and conducting personal interviews with apple and wine-grape producers in California, New York, Pennsylvania, and Washington. They found that changing precipitation patterns, reliance on local markets, and regional location were all factors that impacted the farmers' perceptions.

Impact: The study can be a platform for change and advance dialogues on climate change, especially in local markets where producers and consumers have stronger environmental concerns.

- The study helps to understand the underlying socioeconomic factors and market structures that lead to a divergence in perceptions of climate change and resource problems.
- Acknowledging that human behavior, climate change, and increasingly extreme weather are interconnected is key to climate adaptation and mitigation efforts.

Machine learning helps prepare necessary adaptations to **warming conditions** for farmers and supply chains.

ADOBE STOCK

Problem: **How can farmers and supply chains be prepared to adapt their practices to a warming climate?**

- The average temperature in the United States has increased by approximately 1.5 degrees Fahrenheit in this century compared to the last century.
- Anticipated increases in temperature will likely influence geographical distribution and yield of grain crops.

Findings: Using machine learning—a form of artificial intelligence that enables a computer system to learn from data—a team of plant and meteorology scientists evaluated more than three decades of county-level crop yield data across 18 Midwest and Great Plains states. From this analysis, the team expects that over the next 40 to 50 years, the best conditions for corn and soybean production will shift northward, from Iowa and Illinois to Minnesota and the Dakotas.

Impact: The models can simulate different growing scenarios with variations in, for instance, atmospheric humidity and exposure to extreme temperatures that can impact established practices in planting dates or establishing risk thresholds. The research provides estimates of changes in the best climatic locations for corn and soybean as well as the uncertainty in the modeled estimates. This broad prediction can help all parties along the U.S. grain supply chain be prepared if this shift, which is currently in progress, continues in the coming decades.

Team: *Armen Kemanian, Alexis Hoffman, Chris Forest*

Partners: *Penn State College of Earth of Mineral Sciences*

Competitive Funding: *National Science Foundation/Network for Sustainable Climate Risk Management (SCRiM), USDA NIFA (Agriculture and Food Research Initiative), U.S. Department of Energy*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04710, Accession #1020049*

ADOBE STOCK

Team: *Paul Esker, Ananda Bandara, Dilooshi Weerasooriya, Carl Bradley, Tom Allen*

Partners: *University of Kentucky, Mississippi State University*

Competitive Funding: *United Soybean Board*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04660, Accession #1016474*

Examining the long-term impact of diseases on soybeans to **provide accurate crop loss assessment.**

Problem: **How can losses to soybean crops be measured more accurately to advance research and policy efforts?**

- The United States is the world's primary soybean producer and second-largest importer.
- Quantitative information on crop losses is scarce, hard to obtain, seldom standardized, and a challenge to compile and compare across states, agroecosystems, and regions.

Findings: Researchers examined the long-term impact of soybean diseases on production by analyzing historical soybean loss data and assessing the economic impacts of 23 common soybean diseases from 28 soybean-producing states in the United States from 1996 to 2016.

- They calculated the total economic losses due to soybean diseases in the nation, finding that the losses amounted to more than $95 billion.
- The impact in the northern states—$80.89 billion—was greater than losses in the southern region, which amounted to $14.59 billion.

Impact: The analysis of historical soybean loss data due to diseases helps soybean pathologists and breeders, government and funding agencies, and educators prioritize research, policy, and educational efforts in soybean disease management.

- Accurate crop loss assessment helps in devising appropriate management strategies to ensure farmer profitability, safeguarding the nation's export soybean crop, preserving global food security, and establishing research priorities.

Estimating **potential damages and losses** caused by the invasive spotted lanternfly.

MICHAEL HOUTZ/PENN STATE

Problem: **What is at stake if the spotted lanternfly continues to spread across Pennsylvania?**

The spotted lanternfly—an invasive nonnative insect—feeds on the sap of fruit, ornamental, and woody plants, posing a significant threat to the state's economy.

- It was first discovered in southeastern Pennsylvania in 2014. It has since spread and is confirmed in 26 Pennsylvania counties, all of which are under a state-imposed quarantine. The insect has also been found in parts of the five surrounding states.

Findings: Researchers examined the impact of the spotted lanternfly on the economy, combining data from government reports, crop production experts, industry surveys, and interviews with stakeholders.

- In the quarantine zone, damage is currently estimated to be $50.1 million per year with a loss of 484 jobs. A worst-case scenario increases these damages to $92.8 million per year with a loss of 927 jobs. If it spreads throughout Pennsylvania, damages could reach as high as $554 million, with a loss of 4,987 jobs.

Impact: This study is the first to estimate the potential economic ramifications of the invasive spotted lanternfly and provides guideposts for decision makers in their response to this insect. The potential spread of this pest and the estimated economic damages outlined in this report argue for the continuance of existing programs, the strengthening of research and management efforts, and additional funding to fight this pest.

Team: *Jayson Harper, Timothy W. Kelsey, Lynn Kime, William Stone*

Competitive Funding: *Center for Rural Pennsylvania*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Projects PEN04612 and PEN04633, Accession #1010877 and #1014522; USDA NIFA Smith-Lever Project PEN08103*

ADOBE STOCK

Identifying defense-response genes in green ash trees to **fight the invasive emerald ash borer.**

Problem: **Can native ash tree species in the United States be saved from the emerald ash borer?**

- The larvae of this invasive insect feed under the trees' bark, girdling and killing the trees within four years of infestation.
- Since first appearing in the United States in 2002, this destructive beetle has killed tens of millions of ash trees, but a small percentage of trees survive and may hold clues about how to rescue the species.

Findings: A team of plant geneticists compared gene expression data for resistant versus susceptible green ash genotypes exposed to attack by the beetles. They found that the gene expression response in the inner bark of resistant trees is induced when the emerald ash borer attacks rather than always being present.

- These findings contribute to longer-term research showing that the offspring of trees from certain wild populations, and to a lesser extent the offspring of certain seed parents within populations, exhibited superior resistance to attack by the insect.

Impact: This research will guide geneticists in the effort to selectively breed ash trees to strengthen their resistance, perhaps by quickening their resistance response to ward off the beetles' onslaught.

Team: *John Carlson, Kim Steiner, Di Wu, Jennifer Koch, Mark Coggeshall*

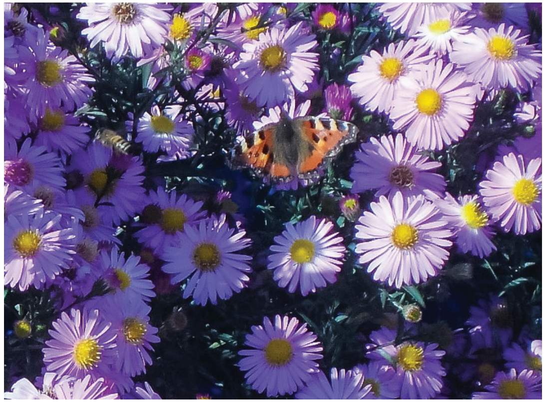
Partners: *The Arboretum at Penn State, Louis W. Schatz Center for Tree Molecular Genetics at Penn State, U.S. Forest Service, University of Missouri*

Competitive Funding: *National Science Foundation (Plant Genome Research Program)*

Other Supporting Sponsors: *Louis W. Schatz Center for Tree Molecular Genetics Endowment*

Federal and State Appropriations: *USDA NIFA McIntire-Stennis Project PEN04717, Accession #020603; USDA NIFA Hatch Multistate Projects PEN04532 and PEN04693, Accession #1000326 and #1018647*

Better indicators of toxicity for pollinators can help to **focus conservation efforts**.



BIGSTOCK

Problem: **How can we better understand and mitigate the role of insecticides in the decline of pollinators and other nontarget insects in recent years?**

- Widespread declines in pollinator populations and other beneficial insects threaten production of pollinator-dependent food crops, wild plants, and natural ecosystems.
- The use of insecticides in agriculture and other settings is believed to play a part in this decline.

Findings: Integrating federal data on insecticide use, toxicity, and crop acreage, a team led by Penn State researchers generated county-level annual estimates of honey bee "toxic load" from 1997 to 2012.

- The total toxic load of insecticides applied to U.S. agricultural landscapes has become significantly more toxic—over 120-fold in some Midwestern states—to honey bees when ingested.
- This increase is largely due to rising use of neonicotinoid seed treatments in corn and soybean.

Impact: The study is the first to identify geographic patterns of insecticide toxicity to bees and reveal specific areas of the country where mitigation and conservation efforts could be focused. The indicator used—bee-toxic load—can serve as an alternative to the commonly used measure of "pounds of insecticide applied" in cases where impacts to bees and other nontarget insects are a concern.

Team: *Christina Grozinger, Maggie Douglas, Douglas Sponsler, Eric Lonsdorf*

Partners: *Dickinson College, University of Minnesota*

Funding: *USDA NIFA (Agriculture and Food Research Initiative), Foundation for Food and Agricultural Research, National Science Foundation/National Socio-Environmental Synthesis Center, USDA Economic Research Service*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04716, Accession #1020527*

ADOBE STOCK

Team: *John Tooker, Heather Karsten, Anna Busch, Margaret Douglas, Glenna Malcolm*

Competitive Funding: *USDA Northeast Region SARE*

Other Supporting Sponsors: *USDA Agricultural Research Service, Penn State College of Agricultural Sciences*

Federal and State Appropriations: *USDA NIFA Hatch Projects PEN04606 and PEN04600, Accession #1009990 and #1009362*

Diversified rotations of cropping systems can **benefit both farmers and the environment**.

Problem: **Can corn and soybean producers use less insecticide and still maintain competitive yields?**

- No-till producers of corn and soybeans often apply insecticides multiple times each growing season to reduce pests that can destroy crops.
- Widespread pesticide use can have significant negative impacts, including elimination of beneficial insect predators and pollinators, losses to adjacent crops, and contamination of groundwater.

Findings: Researchers conducted a six-year comparison of two types of crop rotations under no-till production: standard corn-soybean rotation with preventative insecticides applied twice annually to suppress caterpillars and other pests, and a diverse rotation of corn, perennial forages, and cover crops that received insecticides only as needed.

- Yields produced by the two systems were similar, with the more diverse rotations that promoted predatory insects averaging only about 10 percent reduced establishment of corn plants due to early season pests.

Impact: Diversified crop rotations that avoid preventative insecticides create conditions that promote populations of predatory insects to combat pests. Considering the cost of multiple insecticide applications and an ongoing struggle with commodity prices, this research demonstrates that high-diversity rotations incorporating integrated pest management can compete with low-diversity systems that include preventative insecticides.

Tick tubes **reduce blacklegged tick burdens** on white-footed mice in Pennsylvania.

Problem: **Can the prevalence of Lyme disease infections be reduced with minimal ecological impacts?**

- Lyme disease, caused by a bacterium transmitted to humans from infected blacklegged ticks, is the most common vectorborne disease in the United States. In 2018 Pennsylvania had the highest incidence of infections in the nation with nearly 8,000 confirmed cases.
- Scaling up current tick control strategies is impractical and may adversely impact the environment.

Findings: Researchers evaluated the effectiveness of treating wild white-footed mice—common hosts for blacklegged ticks at immature stages and an important reservoir host for the Lyme disease pathogen—by placing cardboard tubes containing acaricide-treated cotton in their habitats so the mice would use the material in their nests.

- Scientists found that the ticks were eliminated from hosts captured in the treatment plots after tick tube deployment.

Impact: This research demonstrated that the biodegradable tick tubes can be an effective host-targeted alternative to more ecologically invasive measures to control ticks, especially as a part of an integrated pest management plan.

- Reducing the number of ticks on the host white-footed mice can also help decrease the risk of pathogen transmission by ticks to uninfected mice and lower the prevalence of infections in humans who come in contact with blacklegged ticks.

Team: *Erika Machtinger, Jessica Brown, Taylor Miller*

Supporting Sponsors: *Thermacell Repellants, Inc., Pennsylvania Game Commission*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04608, Accession #1010032*

BIGSTOCK

Team: *Elizabeth McGraw, Suzanne Ford, Johanna Ohm, Leah Sigle, Aswathy Sebastian, Istvan Albert, Scott Allen, Stephen Chenoweth*

Partners: *University of Queensland*

Competitive Funding: *National Health and Medical Research Council of Australia*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04608, Accession #1010032*

Research predicts the stability of **mosquitoborne disease prevention**.

Problem: **Can biocontrol interventions be deployed effectively to slow the spread of vectorborne diseases?**

- More than half of the world's population lives alongside *Aedes aegypti*, the mosquito that transmits dengue, Zika, and other often deadly viruses.
- A naturally occurring bacteria, *Wolbachia,* has demonstrated an ability to control the spread of disease, but researchers are concerned that the mosquito could evolve a resistance to the beneficial bacteria.

Findings: A team of international researchers based at Penn State investigated the stability of *Wolbachia*-induced virus blocking, suggesting that this benefit could be sustained over time.

Impact: This research reveals a possible mechanism for the blocking trait in that the newly discovered genes alter the virus's ability to enter cells, replicate within them, and then exit. By defining this mechanism and understanding how selection might act upon it, scientists will be better able to predict the efficacy of *Wolbachia* as a biocontrol agent.

Whole-genome sequencing may help food safety officials **respond faster and more accurately**.

Problem: **How can researchers and public health officials respond more quickly to foodborne illness outbreaks?**

- Approximately two to three million people in the United States are infected each year by *Salmonella*, a diarrheal disease typically acquired through food.

Findings: Researchers used whole-genome sequencing to identify signatures in the genomes in order to rapidly match strains from humans and food. This method also identified mechanisms by which *Salmonella* isolates in Pennsylvania are increasingly resistant to antibiotics.

- Data from Penn State and other labs are stored on the U.S. Food and Drug Administration's GenomeTrakr to allow real-time comparison and analysis to speed up foodborne illness outbreak investigations and reduce consequent illnesses and deaths.

Impact: Comparing and classifying *Salmonella* samples during an outbreak could give health officials the ability to identify possible sources of the disease and more accurately monitor its progress and provide warnings, thus helping to reduce further incidences.

- Demonstrating that *Salmonella* isolates from food are genetic matches to those from ill patients is a critical first step to understanding how a foodborne outbreak occurred.
- This work is assisting the Pennsylvania Department of Health as they increasingly use whole-genome sequencing in their routine workflow.

Team: *Edward Dudley, Andrea Eyler (Keefer), Hillary Mosso (Figler), Lingzi Xiaoli, Nkuchia M'ikanatha*

Partners: *Pennsylvania Department of Health, Penn State Huck Institutes of the Life Sciences, Penn State E. coli Reference Center, Penn State Institute for Computational and Data Sciences*

Competitive Funding: *U.S. Food and Drug Administration*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04644, Accession #1015714*

ADOBE STOCK

VIVEK KAPUR/PENNSTATE

Team: *Vivek Kapur, Sreenidhi Srinivasan, L. Easterling, M. Veerasami, G.Jones, S. Steinbach, T. Holder, M. Vordermeier, A. Zewude, A. Fromsa, G. Ameni, D. Bakker, N. Juleff, G. Gifford, R. G. Hewinson*

Partners: *The Huck Institutes at Penn State; Cisgen Biotech Discoveries Private Limited; University of Aberystwyth, United Kingdom; Addis Ababa University, Ethiopia; World Organisation for Animal Health (OIE), France; United Kingdom Department for Environment, Food and Rural Affairs*

Competitive Funding: *Bill & Melinda Gates Foundation, United Kingdom Department for International Development*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04637, Accession #1014673*

New tuberculosis tests help to make cow vaccination programs **easier and more affordable to implement**.

Problem: **How can vaccination programs be made more accessible to prevent tuberculosis transmission in low- and middle-income countries?**

» Tuberculosis (TB) kills more people around the world than any other infectious disease. Infected cattle can be reservoirs for transmission of the disease to humans through the consumption of unpasteurized dairy products and cohabitation.

» Because the traditional TB test is unable to distinguish infected from vaccinated animals, cattle vaccinations are not commonly practiced. A ˝test and slaughter˝ approach is more common but not always feasible where cattle are a primary source of income and nutrition or because of the animal's cultural and spiritual importance.

Findings: An international team of scientists created a novel skin test that can distinguish between cattle that are infected with TB and those that have been vaccinated against the disease.

Impact: The new test enables the implementation of vaccination programs by providing an alternative to more expensive test-and-cull strategies or the use of antibiotics. It is economical, easy to manufacture and standardize, and has the potential to replace the current standard test that has been in use for close to a century.

Addressing vulnerability risk factors can **strengthen Pennsylvania communities**.

Problem: **How can policymakers and community groups better address social and economic factors that make some populations more vulnerable to risk in the face of a crisis?**

- The coronavirus pandemic has revealed the vulnerability of segments of the population to significant physical, social, and economic upheaval.

Findings: Penn State researchers developed an online tool to assist community leaders and policymakers in understanding and mitigating these vulnerabilities.

- Interactive maps illustrate data on the prevalence of 12 vulnerability risk factors, such as poverty, housing cost burden, lack of broadband internet access, poor healthcare coverage, food insecurity, and others.
- Narrative text and discussion questions facilitate engagement and stimulate thought about how, why, and where the pandemic and resulting disruptions could affect local populations.

Impact: Although growing out of the COVID-19 crisis, the project has a longer-range value. This research and tool will help to:

- Catalyze citizens, civic groups, nonprofit organizations, and the public and private sectors to think about not only how to guide residents through the current crisis but also approaches to address chronic issues affecting various populations
- Strengthen communities, leaving them more prepared to face challenges and recover from unexpected events in the future

ADOBE STOCK

Team: *Cristy Halerz Schmidt, Timothy W. Kelsey, Alyssa Gurklis*

Partners: *Penn State Center for Economic and Community Development, Penn State Extension*

Federal and State Appropriations:
USDA NIFA Multistate Hatch Project PEN04633, Accession #1014522; USDA-NIFA Smith-Lever Project PEN08103

ADOBE STOCK

Team: *Guangqing Chi, Davin Holen, Lance Howe, Kevin Berry, Hannah Henninghausen, Todd Radenbaugh, Gabe Dunham, Luke Smith, Ann Tickamyer, Heather Randell*

Partners: *City of Dillingham, Alaska; University of Alaska, Fairbanks; University of Alaska, Anchorage*

Competitive Funding: *National Science Foundation (Office of Polar Programs)*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04623, Accession #1013257*

Modeling pandemic impacts on Alaskan salmon season helps communities prepare for different scenarios.

Problem: **What can communities do to prepare for demands on medical resources and assess the costs and benefits of mitigation policies in the midst of a pandemic?**

- A small fishing region such as Bristol Bay, Alaska, will typically increase its local population by about three times during the summer fishing season. The town could face potentially huge losses—about $1.5 billion—if the season was canceled due to pandemic mitigation policies.

Findings: As an extension of an existing project in the area, scientists conducted surveys with fishery participants and local residents to better understand the costs and benefits of various mitigation policies. They also evaluated the demand for medical resources and assessed risk perceptions, responses, and preferences to develop pandemic-preparedness scenarios.

Impact: This research will help inform residents and local policymakers about the 2020 season and prepare for the 2021 season and another possible wave of COVID-19. Socioecological modeling can estimate the probability of a COVID-19 introduction and the rate of spread under various parameters, including delayed season openings or partial closures of the commercial fishery.

- The models also provide projections on how quickly area resources could be overwhelmed by an uncontrolled outbreak, as well as under various scenarios of social distancing, both within the fishing fleet while on shore and for the community at large.

Studying bedrock type under forests helps to more **effectively target carbon sequestration efforts**.

Problem: **Can nature-based solutions help us combat climate change?**

- Forests in the United States have the potential to offset as much as 19 percent of annual fossil fuel emissions.
- Increasing concentrations of carbon dioxide are outpacing the ability of oceans and forests to remove carbon from the atmosphere.

Findings: In analyzing more than 23,000 trees from 565 plots on Pennsylvania's state forest and game lands, ecologists found that a forest's ability to store carbon depends significantly on the bedrock beneath. The study concluded that shale bedrock can make more water available to trees, which helps them grow faster.

- Two-thirds of the plots were on sandstone and the other third on shale, reflecting the bedrock ratio of the state's forestland.
- The team identified drivers of live forest carbon dynamics in relation to bedrock using a suite of GIS-derived landscape metrics.

Impact: Forest managers can now use the results of this study to make more informed decisions about where to target conservation to promote more effective carbon sequestration efforts.

- Forests growing on shale bedrock store 25 percent more live, aboveground carbon and can take up about 55 percent more carbon annually than forests growing over sandstone bedrock.

Team: *Margot Kaye, Warren Reed*

Competitive Funding: *National Science Foundation (Susquehanna Shale Hills Critical Zone Observatory)*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04658, Accession #1016433*

WARREN REED/PENN STATE

ADOBE STOCK

Team: *Marc Abrams, Brice Hanberry*

Partner: *U.S. Forest Service*

Competitive Funding: *U.S. Forest Service*

Federal and State Appropriations:
USDA NIFA Hatch Project PEN04658, Accession #1016433

Analysis of historic and current forest inventories reveals **regenerative management strategies** for eastern forests.

Problem: **How can scientists and land managers better address the ecological consequences of increasingly dense forests?**

- The densification of forests by undesirable trees in the eastern United States, which is often blamed on selective browsing by white-tailed deer, threatens the sustainability of many historically important tree species.

Findings: Despite conflicting trends, researchers found that deer browsing has not controlled tree density on a landscape level because certain tree species, whether preferred by deer or not, generally have increased in eastern forests. Exceptions are the fire-adapted species such as oak, hickory, and pine, which have suffered more from a lack of fire.

- The team analyzed U.S. Forest Service data of more than 1,000 forest inventory areas in 26 states east of the Mississippi River, calculated changes in tree stocking and species, and compared deer browse preferences with trends in species composition from current and historical tree surveys from as early as 1620.

Impact: This research may greatly change how scientists and forest managers view the role of deer in the ecology of eastern forests, redirecting management goals to include reducing the overstory density of undesired tree species and restoring natural fire cycles that help promote the historically dominant trees in the eastern United States. A reduction in deer density may help promote some desirable tree species but may also exacerbate the densification problem.

Weighing the impacts of anti-sprawl policies can help land-use planners **decrease water pollution**.

ADOBE STOCK

Problem: **How can growing urban areas responsibly meet water quality regulations to maintain healthy downstream waterbodies?**

» Governments create urban growth boundaries to help restrict land development. This decreases negative impacts on people and the environment and regulates the role of land in mitigating nutrient pollution or the delivery of nitrogen, phosphorus, and sediment to local and downstream waterbodies, which can cause numerous environmental problems.

Findings: Penn State researchers used water quality modeling with land-use simulations to investigate the impact of anti-sprawl policies. Their results showed that attempts to limit sprawl may also increase water pollution with higher-density development creating runoff from more impervious surfaces. This problem can be exacerbated when agriculture is allowed to continue business as usual outside the growth boundaries.

Impact: The research revealed the tradeoffs that land-use planners, especially in urbanizing and urban-fringe counties, will need to weigh between objectives for managing urban growth and those for managing water quality.

» Giving land-use planners some ability to manage where and when land-use development takes place can help regions meet water quality regulations.

Team: *Douglas Wrenn, H. Allen Klaiber, David Newburn*

Partners: *Ohio State University, University of Maryland*

Competitive Funding: *U.S. Forest Service Northern Research Station, National Science Foundation, James S. McDonnell Foundation*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04631, Accession #1014400*

STEVAN EARL

Team: *Lauren McPhillips, Stevan Earl, Nancy Grimm, Rebecca Hale*

Partners: *Global Institute of Sustainability, Arizona State University; Idaho State University*

Competitive Funding: *National Science Foundation/Urban Resilience to Extremes Sustainability Research Network, National Science Foundation/Central Arizona-Phoenix Long-Term Ecological Research*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04726, Accession #1020769*

Understanding differences across U.S. urban watersheds aids in **planning better stormwater management.**

Problem: **How can urban and suburban areas better prepare for increased frequency and intensity of extreme rainfall events?**

- Flash floods caused by excessive runoff over impervious surfaces not only can damage property but could also be deadly. Responses to these intense and sudden changes in streamflow, or flashiness, depend on variations in climate and biophysical context as well as stormwater management practices.

Findings: Engineers and ecologists studied how hydrologic characteristics varied with urban development in arid environments.Urbanization in these watersheds surprisingly increased water retention and reduced flashiness.

- They analyzed 14 years of flow records for 19 watersheds in central Arizona, both urban and nonurban and ranging in size from less than a square mile to 175 square miles.

Impact: The sharp contrast between eastern and western urbanization in the United States uncovered by this research provides significant lessons in the nuances of stormwater management for engineers and planners. This unique study documented for the first time:

- Reduced flashiness of arid urban streams in the West, a pattern that is opposite of that typically seen in eastern cities
- The significant role of "dry weather flows" from sources other than rain events and the influence of stormwater management efforts that were integrated into urban growth

Novel laminated antimicrobial film could **improve the safety** of food products.

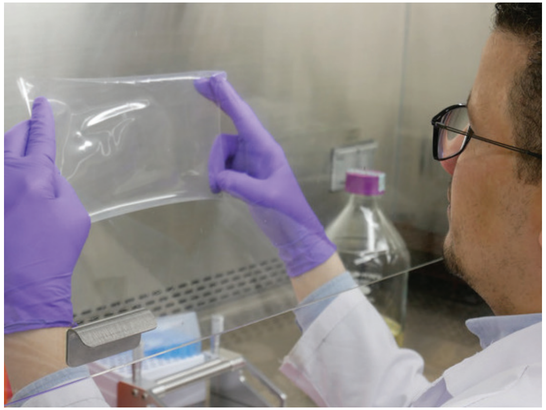
Problem: **Can we use food packaging to help reduce pathogens in the food supply?**

- Approximately 76 million cases of foodborne illnesses occur each year in the United States, resulting in 300,000 hospitalizations and 5,000 deaths.

Invention: Researchers discovered a way to adhere an edible film infused with an antimicrobial compound onto plastic that is typically used to vacuum-package foods such as meat, poultry, and fish.

- The antimicrobial layer is composed of pullulan, produced by *Aureobasidium pullulans* and already approved for human consumption. The pullulan layer allows for a gradual release of the antimicrobial, providing continuous bacteria-killing activity.

Application: Testing their laminated antimicrobial film, the team found that it significantly reduced foodborne pathogens on experimentally inoculated surfaces of raw and ready-to-eat muscle foods after long-term refrigerated storage. The resulting film provides antimicrobial properties, strength, and other desirable properties associated with vacuum-packaging materials and may be of interest to packaging companies, food processors, and regulatory agencies.



CATHERINE CUTTER/PENN STATE

Team: *Catherine Cutter, Abdelrahim Hassan*

Competitive Funding: *U.S.-Egypt Higher Education Initiative*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04666, Accession #1017568*

ADOBE STOCK

Team: *Federico Harte, Charith Hettiarachchi, Grace Voronin*

Supporting Sponsors: *Dairy Management Inc.*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04708, Accession #1019852*

Novel powdered milk method yields better frothing agent.

Problem: **Can synthetic ingredients in food emulsifiers and foaming agents be replaced with "clean label" ingredients that are still cost-effective?**

- Concerns about "clean labels" are growing in the food industry.
- Although there is no evidence to suggest that synthetic ingredients used as emulsifiers and foaming agents are harmful, consumers tend to prefer foods with ingredients they recognize.

Invention: Researchers invented a novel method of using high-pressure jet processing to produce skim milk powders with enhanced properties and functionality.

- The team used a device that pressurizes pasteurized skim milk using an intensifier pump to spray the milk through a diamond or sapphire nozzle.
- The sprayed liquid forms an aerosol as the fine droplets collide with the air and then is quickly dried to obtain skim milk powders.

Application: In comparison to liquids, powders possess a broader spectrum of applications due to the inherent shelf-life stability and lower cost associated with their transportation and storage.

- Among the most promising properties researchers observed in the skim milk powder produced using this process were marked increases in foam expansion and foam-volume stability, making it a great candidate for use in lattes. The team continues to research how to scale up this process in order to provide food manufacturers with a cost-effective "clean" ingredient.

College researchers are forming **powerful networks of expertise** to shape the future of agricultural science research.

Guiding synthetic biology investments for federal agencies, biotech companies, and emerging faculty

- Participating in a working group of more than 80 scientists and engineers from 30 universities and 12 companies to provide the Engineering Biology Research Consortium Roadmap
- Helping to improve our food supply, public health, and environment; fuel the economy; and maintain U.S. leadership in synthetic biology

Empowering women farmers in northern Ghana through peanut production

- Working with the Savannah Agricultural Research Institute in Nyankpala, Ghana, to conduct a two-year study as a part of the USAID-funded Feed the Future Innovation Lab for Peanut Research at the University of Georgia
- Providing critical evidence regarding the challenges and barriers faced by women in the peanut value chain along with recommendations to help enhance productivity and time efficiency

Lending expertise to stop a destructive bacterial disease in lettuce

- Contributing to a USDA-funded multi-institutional research project led by University of Florida's Institute of Food and Agricultural Sciences to study disease resistance and various interactions between lettuce and bacterial leaf spot of lettuce
- Developing sustainable and long-term solutions to battle an unpredictable and devastating disease in lettuce

Roadmap
Penn State Team: Howard Salis
Funding: National Science Foundation/ Engineering Biology Research Consortium; USDA NIFA Hatch Multistate Project PEN04671, Accession #1017582

Peanut Farmers
Penn State Team: Leland Glenna, Paige Castellanos, Leif Jensen, Janelle Larson
Funding: USAID; USDA NIFA Hatch Multistate Projects PEN04612 and PEN04623, Accession #1010877 and #1013257

Lettuce Disease
Penn State Team: Carolee Bull, Germán V. Sandoya-Miranda, Maria Gorgo-Gourovitch, Emma Rosenthal
Funding: USDA Agricultural Marketing Service (Specialty Crop Multi-State Program)

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Multidisciplinary and Multiscale Approach

- A science-to-practice platform centered on frameworks that build a capacity of expertise in understanding **landscape-scale interactions** and how those interactions occur across scales
  - Data: the **theory and methods of data acquisition and analysis**
  - Models: **coupling and translating information across biophysical and socioeconomic models**
  - Discovery: **making acquired data and interoperable models accessible** to academic and nonacademic audiences within and beyond the University
- A flexible framework that allows investigators to dynamically shape their collaborations in order to address issues as they emerge, morph, and shift within changing contexts

The newly established Institute for Sustainable Agricultural, Food, and Environmental Science (SAFES) **convenes wide-ranging expertise at Penn State** to address complex landscape-level challenges.

SAFES is housed within the College of Agricultural Sciences, situating it at the epicenter of research that is tackling the extraordinarily complex, interconnected challenges of predicting vulnerabilities in systems, feeding a growing population, environmental resilience, and economic sustainability.

The mission of SAFES is to provide a synthesizing **science-to-practice platform** for a collaborative community of researchers, students, and stakeholders in their discovery of responsible and sustainable policy options, business management solutions, and best practices.

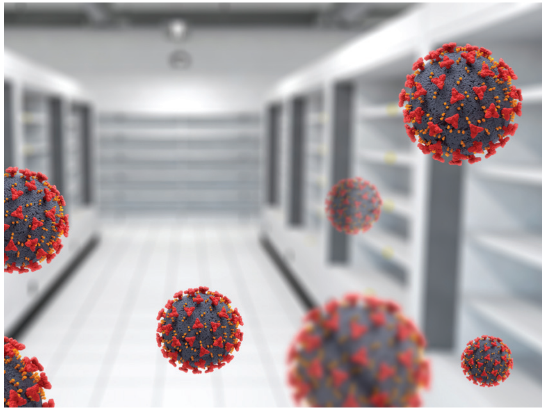
- The institute will serve as an entry point for connecting diverse knowledge groups—from University colleagues and students to external stakeholders—with the aim to develop decision-support and policy innovations through landscape-level analyses.
- With this unified effort directed at the complex, critical issues facing working landscapes today and in the near future, SAFES can accelerate much-needed and timely discoveries.

Learn more about SAFES at **agsci.psu.edu/safes**.

SAFES rapidly deploys the college's expertise to address **COVID-19 impacts on agricultural, food, and environmental systems**.

In March 2020, as the world faced unexpected challenges to these systems—supply chain disruptions, processing facility closures, interrupted agricultural production practices, threats to food security in vulnerable communities, and more—SAFES assumed the mantle of an organizing force. In a rapid response as its first initiative, the institute competitively awarded seed grants to teams addressing critical pain points caused by the pandemic.

- 10 seed grants, totaling $189,00 were awarded to principal investigators in six departments.
- Topics included:
  - Developing decision-support tools for crisis response
    - To reduce current bottlenecks in the agricultural supply chain
    - To project impacts of rapid reduction of farm milk production
  - Coupling models of food supply networks and agricultural markets to simulate the potential for future disruptions
  - Analyzing social media trends of food security and impact on food systems in vulnerable communities
  - Monitoring local wastewater treatment plants for virus prevalence in the population
  - Assessing impact on consumers' attitudes toward local food and the environment
  - Addressing how farmers respond to crises, from how they handle stress and uncertainty to the decisions they make regarding soil management



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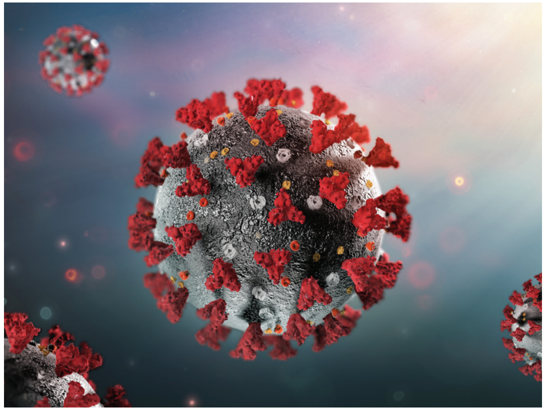
Awardees

Patrick Drohan
David Abler
Stephan Goetz
Heather Preisendanz
Yuning Shi
Chad Dechow
Martina Vecchi
Nicole Webster
Sharifa Crandall
Suzanna Windon



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Lead Researchers

Suresh Kuchipudi
Troy Sutton
John Hayes
Ottar Bjornstad
Anthony Schmitt

Researchers in the college quickly **adapted their expertise** to address an unknown and dangerous virus.

In response to the coronavirus pandemic, veterinary and biomedical scientists and food scientists in the college quickly redirected their research to contribute to worldwide efforts in understanding the SARS-CoV-2 virus, how it is transmitted, how it can be more quickly detected, and how to better treat those suffering from COVID-19, the disease caused by the virus. Researchers in the college are:

- Studying the potential for SARS-CoV-2 to infect/spread among livestock
- Better controlling the inflammatory response caused by COVID-19 to alleviate the deadliest and medically burdensome feature of the disease
- Evaluating the sudden loss of smell, a cardinal symptom of COVID-19, for a rapid and inexpensive self-assessment and objective medical technique for disease diagnosis
- Developing a virus particle mimicking intranasal vaccine against SARS-CoV-2
- Optimizing COVID-19 control strategies in public transportation enabled by individual-level data analytics and simulations
- Developing an animal model to understand transmission and build countermeasures to aid in the creation of a coronavirus vaccine
- Increasing understanding of COVID-19 through K–12 online learning modules and community education

Research efforts in the College of Agricultural Sciences **embrace discovery and application** to address critical challenges impacting agriculture, natural resources, and the environment.

» College research programs synergize the development of interdisciplinary collaborations by encouraging teams to extend beyond existing paradigms and generate new ideas that are highly competitive for extramural funding.

» Graduate programs produce the next generation of scientists and educators to advance agricultural sciences and discover innovative solutions to future global challenges.

528 ENROLLED **GRADUATE STUDENTS**

10 **INTERCOLLEGE** GRADUATE PROGRAMS

18 **COLLEGE** GRADUATE PROGRAMS

72 **POSTDOCTORAL** SCHOLARS

265 **FACULTY** WITH **RESEARCH** APPOINTMENTS

9 **DEPARTMENTS**

7 **SERVICE** LABORATORIES

3 **RESEARCH & EXTENSION CENTERS**

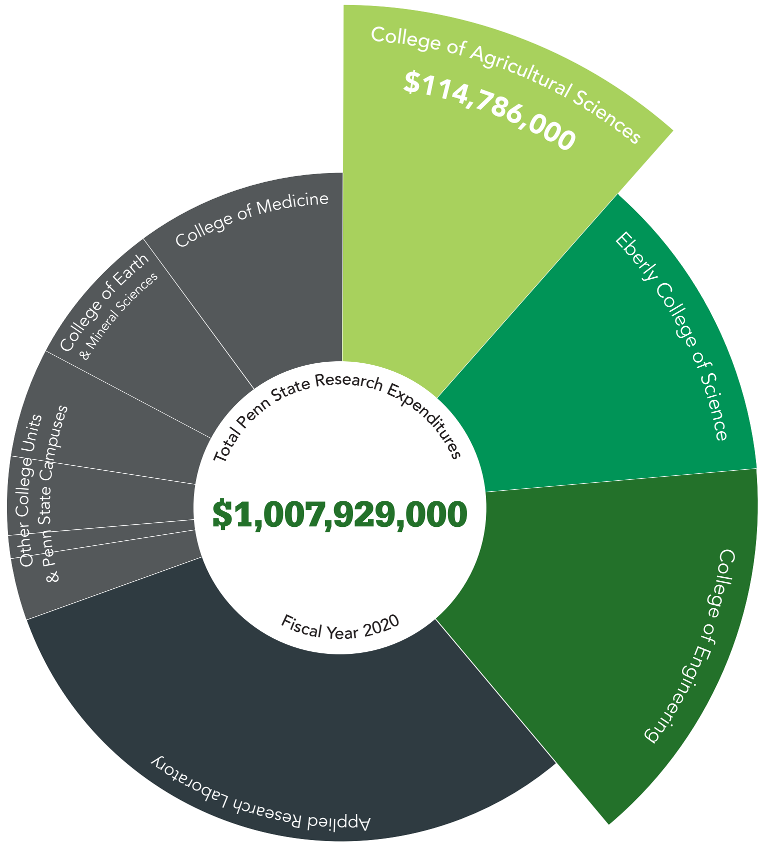
695 **REFEREED** JOURNAL ARTICLES PUBLISHED

19 **PATENT** APPLICATIONS

14 **TECHNOLOGY** DISCLOSURES

DATA FROM THE OFFICE FOR RESEARCH AND GRADUATE EDUCATION FOR FISCAL YEAR 2019/2020

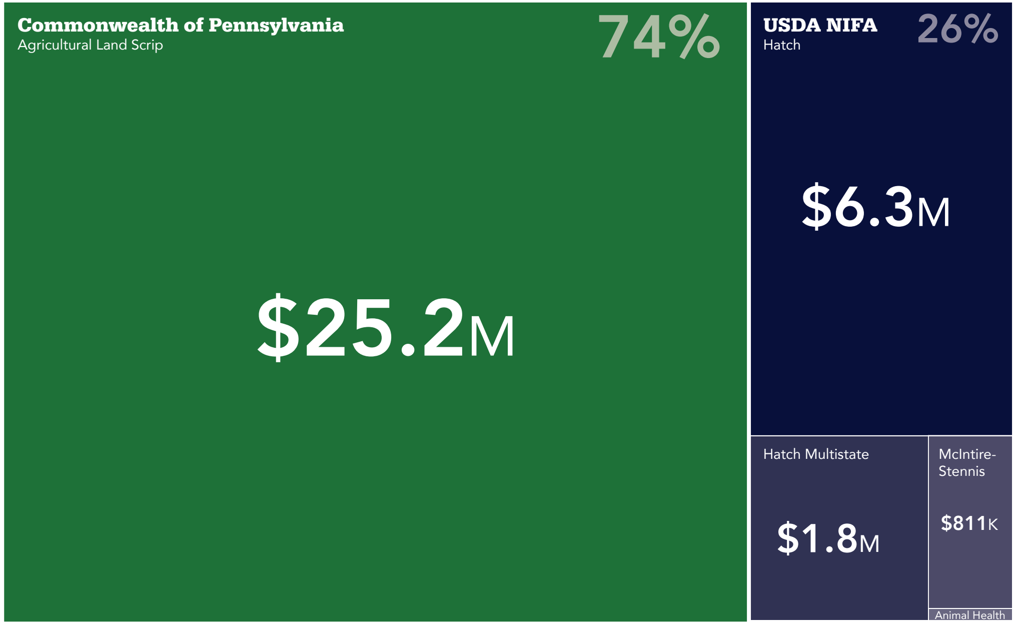
As one of more than 20 units contributing to Penn State's research expenditures, the College of Agricultural Sciences has consistently been among the **top three highest-performing college units** for the past five years.



DATA FROM THE PENN STATE OFFICE OF THE SENIOR VICE PRESIDENT FOR RESEARCH

The College of Agricultural Sciences is the **only college in the Penn State system** to receive federally appropriated funds to support faculty research.

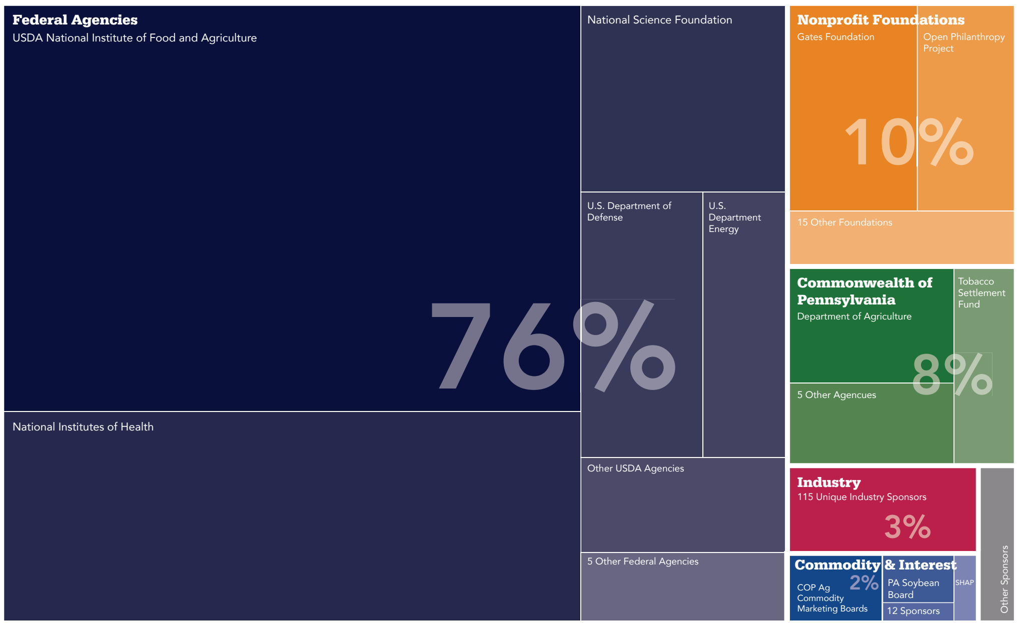
- The federal government has appropriated funds **specifically to support agricultural research** at land-grant universities since 1887.
- The Commonwealth of Pennsylvania has **exceeded the required match** for federal appropriations by at least two-and-a-half times since 2008.
    - Funding from the **state accounted for approximately 74 percent** of the total amount of government appropriations in the 2019/2020 fiscal year.



CREDIT: FEDERAL AND STATE APPROPRIATIONS FOR FISCAL YEAR 2019/2020

Researchers in the College of Agricultural Sciences also support their discoveries and innovations through competitive grants that bring collaborative teams of investigators together from across Penn State, the nation, and the globe.

- Research, outreach, and instruction in the College of Agricultural Sciences was supported by a **total of $134.9 million** in extramural grants. Research awards accounted for more than two-thirds of this funding.
- Grants awarded from **federal agencies accounted for approximately 76 percent** of the total research awards.
  - The USDA National Institute of Food and Agriculture, National Institutes of Health, and the National Science Foundation are the college's largest sponsors.



CREDIT: SPONSORS OF COMPETITIVE GRANTS FOR FISCAL YEAR 2019/2020

Major competitive extramural grants awarded to College of Agricultural Sciences researchers help to **drive research inquiry** as they pursue tomorrow's solutions.

Thriving Agricultural Systems in Urbanized Landscapes

An interdisciplinary team led by Penn State researchers was awarded nearly $9 million by the USDA NIFA Agriculture and Food Research Initiative under the Sustainable Agricultural Systems Program to study how food systems in metropolitan regions could remain economically and environmentally sustainable. They are collaborating with partners at University of Maryland, Virginia Tech, Ohio State University, and the Stroud Water Research Center to employ their unique "shared discovery" approach, a collaborative co-learning process allowing researchers and stakeholders to explore research design, results, and decision-support tools developed from a collective effort. (Principal Investigator: David Abler)

Reducing the Impact of the Spotted Lanternfly in Specialty Crops in the Eastern USA

A $7.3 million grant from the USDA NIFA Specialty Crop Research Initiative was awarded to an interdisciplinary, multi-institutional team led by Penn State to research and develop strategies to combat the invasive insect that threatens grape, tree fruit, hardwood, and nursery industries. Growers and landowners working with the researchers are providing an additional $5 million in matching investments to aid in arriving at strategies for sustainable, long-term management of this pest. (Principal Investigator: Julie Urban)

Integrated Management of Emerging Seedborne Bacterial Diseases

An interdisciplinary team of researchers across 10 institutions and led by Penn State was awarded nearly $4 million by USDA NIFA Specialty Crop Research Initiative to study bacterial pathogens causing leaf spot diseases that are damaging valuable agricultural crops such as watermelon and pumpkin. An additional $3 million in matching investments from seed companies and associated industries along with over $1 million from the universities involved supplement this award. (Principal Investigator: Carolee Bull)

PennState
College of Agricultural Sciences

Office for Research and Graduate Education
College of Agricultural Sciences
The Pennsylvania State University

Read more about these and other stories of impact from Penn State College of Agricultural Sciences at **agsci.psu.edu/research/impacts**.

Cover images from Adobe Stock

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