Shortening the Distance Between Discovery and Impact

Penn State AgScience Research

PennState
College of Agricultural Sciences

Contents

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

The College of Agricultural Sciences conducts research that **addresses the most significant challenges to our economic, social, and environmental well-being**. We are proud to share highlights of this work in the following report. The research that follows is captured among six thematic areas and showcases the impact this research can have in providing solutions to some of the most urgent issues of our time, including **resilience to climate instability**, **soil health**, **nutritional security**, and **environmental protection** and to **ensure the profitability of our producers** and the **security of both rural and urban communities**. We continually strive to embrace emerging technologies and innovations that will foster a new paradigm of how we grow our food to provide nutritional security while at the same time protecting our environment and natural resources. We believe strongly that agriculture provides real solutions to these challenges, which will be applicable to our state, nation, and globe.

We have a responsibility to leverage the significant resources from state and federal appropriations through the Agricultural Experiment Station, and we continually seek opportunities to expand our research efforts into the next phase of discovery and deliver timely solutions to the stakeholders and citizens of our Commonwealth. This report documents this commitment and demonstrates the innovation and drive of our faculty, staff, and students.

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USDA National Institute of Food and Agriculture
U.S. DEPARTMENT OF AGRICULTURE

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The following stories of impact are organized into six broad themes. Each area 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 issue from different angles.

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

- Finding balanced solutions to sustain a growing global population

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

- Taking a comprehensive approach to solutions that ensure the availability and access to safe, affordable, and healthy food

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

- Coordinating a wide spectrum of expertise to ensure diversity across the genes of individuals, entire populations of species, and the ecosystems in which they live

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

- Addressing health as an integrated challenge at the intersections between people, animals, plants, and the environment they inhabit

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

- Strengthening the development and resilience of communities and the individuals within them, especially as they are faced with social, economic, and environmental shocks and stresses

Integrated Ecosystems that investigate complex scenarios and model holistic solutions

- Advancing data-driven solutions for better management of complex agricultural and natural resource systems

Site-specific recommendations for fertilizer provide **balanced solutions for farmers**.

Problem: **How can farmers be more precise in applying fertilizer to corn fields with cover crops?**

- Knowing how much fertilizer to apply is complicated by a lack of available tools to accurately predict the correct amount of nitrogen that is needed for crops in any given year.

Findings: Researchers developed a prototype for an online decision support tool that corn growers can use to adjust nitrogen fertilizer applications. The system uses measurements that farmers and agronomists can easily collect in the field to predict the nitrogen contributed by the soil and cover crops.

- The team calibrated their tool using a dataset of 73 observations from nine cover crop experiments conducted over a three-year period.

Impact: In the last decade, the wide use of cover crops in rotations with corn has resulted in reductions in both nutrient pollution and sedimentation. This nitrogen recommendation system is an important step toward refining fertilizer applications to meet cash crop demands.

- Reducing over-application of fertilizer minimizes nitrogen pollution of waterways and helps to boost farmers' bottom lines.

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Partner: *Ursinus College*

Competitive Funding: *USDA National Institutes of Food and Agriculture (NIFA) (Agriculture and Food Research Initiative [AFRI]); USDA NIFA (Organic Agriculture Research & Extension Initiative [OREI]); USDA NIFA (Sustainable Agricultural Systems [SAS]); USDA Northeast Sustainable Agriculture Research and Education (NE SARE); USDA Natural Resources Conservation Service (NRCS) (Conservation Innovation Grants); National Fish and Wildlife Foundation*

Federal and State Appropriations: *USDA NIFA Hatch Projects PEN04571 and PEN04600, Accession #1003346 and #1009362*

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Competitive Funding: *USDA NE SARE; Pennsylvania Vegetable Growers Association; State Horticultural Association of Pennsylvania (SHAP)*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04653, Accession #1016510 and Hatch Project PEN04723, Accession #1020664*

Precision irrigation technology can **conserve water and improve crop quality and yield**.

Problem: **How can food crop production keep pace with a growing human population while water resources are becoming increasingly limited?**

- Agriculture accounts for approximately 80 percent of the nation's consumptive water use in the United States.
- Inefficient water usage, including both over- or under-irrigation, can impact production costs and environmental quality as well as crop yield and quality.

Findings: In a study involving fresh-market tomatoes, researchers tested the effect of four irrigation-scheduling treatments using an internet of things, or IoT, system to monitor soil moisture sensors. When soil moisture levels reached a specified threshold, an automated precision irrigation system would then activate.

- They reported that throughout the growing season, the overall water-use efficiencies of the methods ranged from 22–28 percent above the control, and they produced 15–22 percent higher marketable fruit yield than normal.

Impact: This simple and relatively inexpensive technology demonstrates how precision agriculture technologies can avoid plant water stress at critical growth stages based on site-specific conditions.

Innovative cover crop strategies can help organic growers **minimize greenhouse gas leaks**.

Problem: **How can growers help to reduce potent greenhouse gas (GHG) emissions that may result from organic agriculture practices?**

- Organic agriculture relies on microbial cycling of nutrient inputs from legume cover crops and applications of animal manure, a combination of practices that can curtail nutrient runoff and soil erosion but at the same time release nitrous oxide.
- Nitrous oxide is a greenhouse gas that is about 300 times better at trapping heat than carbon dioxide.

Findings: Researchers measured soil nitrous oxide emissions for two growing seasons in four corn-soybean-winter grain rotations, with tillage, cover crop, and manure-management variations typical of North American organic agriculture.

- They found a significant "leak" from the combination of nitrogen inputs from the cover crops and the manure prior to corn planting due to the soil's inability to hold nitrous oxide and convert it to harmless nitrogen before escaping to the atmosphere.

Impact: As a result of their findings, the researchers proposed several strategies to reduce those unintended consequences, including removing a fraction of the cover crop's aboveground biomass before corn planting. By preventing the co-location of fresh biomass and manure they decreased nitrous oxide emissions by 60 percent.

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Federal and State Appropriations: *USDA NIFA Hatch Projects PEN04571, Accession #1003346*

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Competitive Funding: *USDA NIFA (OREI); Organic Farming Research Foundation; USDA NIFA (Organic Transitions); College of Agricultural Sciences (Strategic Networks and Initiatives Program)*

Federal and State Appropriations: *USDA NIFA Hatch Projects PEN04571, PEN04606, and PEN04600, Accession #1003346, # 1009990, and #1009362*

"Farm tuning" cover crops for soil and climatic **conditions can improve plant, soil health**.

Problem: **Why do cover crop mixes produce profoundly different results depending on when and where they are planted?**

- Cover crop mixtures comprised of multiple species planted in rotation between cash crops provide a suite of benefits—such as erosion reduction, weed control, addition of carbon and nitrogen to the soil, and support of beneficial organisms.

Findings: Researchers worked with eight participating farmers to compare a standard five-species cover crop mix to a "farm-tuned" mixture of the same species with seeding rates adjusted to achieve farmer-desired services.

- They found that growing degree days and nitrogen affected how the mixtures grew, countering a prevailing assumption that seeding rates had the biggest impact on ecosystem services.
- Their results showed that when soil inorganic nitrogen availability is high at the time of cover crop planting, highly competitive species can dominate mixtures, which could potentially decrease services provided by other species, especially legumes.

Impact: The knowledge gained from this study—novel due to its breadth and complexity—will be used to design custom seed mixes with predictable growth from the different species.

- Recommendations from the study can help farmers choose cover crop species and seeding rates according to their inorganic nitrogen in soil and planting dates to ensure the provision of desired ecosystem services.

Discovery of how insects trick plant defenses can **guide management tactics**.

Problem: **Can a plant's natural defenses be leveraged to enhance protection against environmental stressors?**

- Plants can protect themselves from insect herbivores by attracting natural enemies to damaged plants and alerting neighboring plants.

Findings: Tomato fruitworm caterpillars can silence host plant defense mechanisms, allowing the insect to devour the undefended plant. The researchers studied how the enzyme glucose oxidase, found in tomato fruitworm caterpillars' saliva, can affect plant stomata, which regulate leaf temperature, gas exchange, and water content.

- Using pharmacological, molecular, and physiological approaches, the researchers were able to show that this salivary enzyme plays a key role in insect-induced stomatal closure and likely the reduction of several important defensive emissions.

Impact: This study is the first to use CRISPR/Cas9-mediated gene editing to study the function of an insect salivary enzyme and determine a role in plant defense.

- This work uncovered a new strategy whereby an insect uses saliva to inhibit the release of airborne plant defenses through direct manipulation of stomata.
- The results yield insights into the abilities of crop plants to withstand additional stressors such as climate change.

ADOBE STOCK

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Competitive Funding: *National Science Foundation (NSF) (Plant-Biotic Interactions); NSF (Cellular Dynamics and Function); NSF (Enabling Discovery through GEnomics [EDGE]); USDA NIFA (AFRI)*

Federal and State Appropriations: *USDA NIFA Hatch Projects PEN04609, PEN04608, and PEN04732, Accession #1010058, #1010032, and #1021883*

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Federal and State Appropriations: *USDA NIFA Hatch Project PEN04757, Accession #1024573*

Better knowledge of plant defenses against pests could **reduce pesticide use**.

Problem: **How can growers leverage plants' natural defenses for biocontrol of insects?**

- Pesticides may be toxic and are potentially hazardous to humans, other nontarget organisms, and the environment.

Findings: This research investigated the influence of goldenrod's chemical defenses in preventing gall flies from inducing galls, which are tumor-like growths on the plant that provide nutrition for the fly larvae but decrease the plants' ability to reproduce.

- The researchers exposed almost 300 goldenrod plants comprising 11 genetic types—or genotypes—to male flies and previously-mated females and tracked gall formation.
- They found that the plants respond to sex pheromones from the flies by strengthening—also known as "priming"—their chemical defenses to prevent females from laying eggs and inducing galls. However, the team also learned that the insects might have the upper hand by detecting the plants' chemical defenses and avoiding the "primed" plants.

Impact: The findings could have practical applications in agriculture, perhaps enabling us to enhance crop plants' defenses against pests without the need for environmentally disruptive pesticides.

Boosting flavonoids in sorghum roots may lead to **frost-resistant crops**.

Problem: **How can farmers battle unpredictable weather patterns to prevent crop loss?**

- Sorghum is the fifth most valuable cereal crop globally and can be used for human food, animal feed, and bioenergy. However, even a mild frost can reduce yield and grain quality.

Findings: Earlier research had shown that flavonoids produced by the roots of some sorghum plants allow the plant to adapt and survive when exposed to stresses such as fungi, insect feeding, or frost. Researchers grew selected lines of sorghum to test whether interactions between flavonoids and soil microbes can influence the plant's ability to adapt when it perceives cold or frost above ground.

- Researchers found evidence that plant genetic variation influences root flavonoids as well as the composition of the soil microbial community in the vicinity of the plant roots and that low temperatures affect these relationships.

Impact: The study's findings can lead to developing a frost-resistant line of this crop, reducing the crops' vulnerability and helping to ensure protection from changing weather to maximize farmers' profits.

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Competitive Funding: *USDA NIFA (Sun Grant Program); USDA NIFA (AFRI); USDA NIFA (Crop Protection and Pest Management); Indian Council of Agricultural Research*

Federal and State Appropriations: *USDA NIFA Hatch Projects PEN04330, PEN04613, PEN04402, and PEN04571, Accession #0218342, #1010654, #0222582, and #1003346*

ADOBE STOCK

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Competitive Funding: *NSF (Plant Genome Research Project)*

Federal and State Appropriations: *USDA NIFA Hatch project PEN04569, Accession #1003147.*

Studying genetic differences to understand how **plant diversity can aid in disease tolerance**.

Problem: **How can we ensure the adaptability of plant populations facing increasing disease pressures?**

- Molecular geneticists have known for about a decade that genomic structural variants, involving large deletions or translocations in chromosomes, can play important roles in the adaptation and speciation of both plants and animals, but their overall influence on the fitness, or ability of plant populations to survive, is poorly understood.

Findings: Researchers analyzed and compared chromosome-scale genome assemblies of 31 naturally occurring individuals from four divergent populations of *Theobroma cacao*, the long-lived tree species that is the source of chocolate.

- They observed more than 160,000 structural variants, most of which were detrimental to the fitness of the plant and therefore constrained adaptation. They also detected several variations in the genomes that may contribute to local adaptation mainly through traits involved in pathogen resistance.

Impact: This study provided critical data and analyses needed to understand the evolutionary significance of structural variation in all plants.

- The findings from this research will be a valuable resource for molecular geneticists and plant breeders in developing varieties that are resistant to emerging and persistent diseases that threaten valuable crops like cacao.

Strengthening local and regional food chains to **enhance food security**.

Problem: **Can cities help meet demand for food despite limited agricultural space?**

- In 2018, 82 percent of the U.S. population lived in urban areas, with an anticipated increase to 89 percent by 2050. With growing populations and affluence, urban food demand will increase, presenting considerable challenges to achieving economic, environmental, and social sustainability.
- The COVID-19 pandemic exposed weaknesses in food supply chains and sharpened the focus on localizing food systems.

Findings: Researchers analyzed the nutritional needs of the population of Chicago based on 28 nutrients and calculated how much food could be produced in the city by maximizing urban agriculture practices such as rooftop gardens and community plots. They also calculated how much crop land would be needed adjacent to the city to grow the rest.

- The findings suggest that urban agriculture can help support food supply chains for many major American cities; however, it would be unrealistic for such practices to meet all nutritional needs given current urban agriculture practices, but they add diversity to diets and provide key nutrients.

Impact: The study was the first to evaluate land required to meet food demand while accounting for a range of nutritional needs instead of only calories or quantities. Their findings illustrate how urban agriculture can realistically result in positive nutritional outcomes by using land not currently used for food production.

ADOBE STOCK

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

Promoting **more robust food environments** to reduce poor health outcomes.

Problem: **How can healthier food options be made available in rural and low-income regions?**

- The composition of the food environment—the type, variety, and prices of available foods—can influence household food choices and the ability of consumers to access and afford more nutritious diets.
- Limited availability of affordable and healthy foods can contribute to poor health outcomes, especially obesity rates.

Findings: A team of researchers examined the food environment for residents in eight counties in the Mississippi Delta, a region that has some of the greatest income inequality, highest rates of poverty, and one of the highest obesity rates in the U.S. Their study focused on Supplemental Nutrition Assistance Program (SNAP)-accepting establishments, which were predominantly convenience stores across all of the counties.

- The team used a retail environment audit instrument to evaluate differences in prices and availability of healthy foods.
- For all food groups, the scientists found a significant gap between scores for convenience stores and scores for supermarkets and grocery stores, and the difference was most striking for fruits and vegetables.

Impact: These findings will be useful for developing interventions in the food environment, not only in the Mississippi Delta but also for other regions of the country where convenience stores and dollar stores are most common.

Pulsed ultraviolet light can be a low-risk method to **improve food safety**.

Problem: **How can poultry producers reduce the risk of disease-causing bacteria?**

- Nine percent of all foodborne illness in the U.S. is associated with eggs. Every year in the U.S., an average of 287 eggs are consumed per person, and more than 14.1 billion eggs are incubated to produce chicks for the egg and poultry meat industries.

Findings: Researchers explored the use of pulsed ultraviolet (UV) light to kill pathogens on eggshells. The surfaces of shell eggs were inoculated with nonpathogenic bacteria strains used for research and were treated with pulsed ultraviolet light derived from a xenon flashlamp. Eggs were exposed on a modified egg-carrying conveyor that provided complete rotation of eggs under the flashlamp.

- The team learned that pulsed UV light, delivered at high intensity, resulted in faster and greater microbial reduction on the eggshell surface than what is reported for conventional UV light treatment.
- They also found no negative effects on hatching eggs and the embryos and chicks derived from treated eggs, even at 10 times the UV-light intensity.

Impact: Without water or chemical sanitizers, this scalable technology can achieve equal or greater microbial reductions than some currently available technologies. This decontamination method can be used with both table and hatching eggs to improve food safety.

ADOBE STOCK

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Federal and State Appropriations: *USDA NIFA Hatch Project PEN04696, Accession #1018953; Hatch Multistate Projects PEN04714 and PEN04740, Accession #1023215 and #1020402*

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Federal and State Appropriations: *USDA NIFA Hatch Project PEN04752, Accession #1023328; Hatch Multistate Project PEN04731, Accession #1022444*

Identifying markers of antibiotic resistance **to make meat and milk products safer.**

Problem: **How is the food supply threatened by antimicrobial resistance?**

- Resistance to antimicrobials is one of the top 10 global public health threats facing humanity, decreasing the effectiveness of medicines and making infections harder to treat.

Findings: Researchers examined dairy cows within an area contaminated by an environmental disaster involving 11 billion gallons of mining waste, which affected drinking water supplies.

- The scientists compared the relative abundance and prevalence of bacterial antimicrobial-resistance genes in the contaminated cattle with those on an unaffected farm, and they found that exposure to heavy metal contamination results in the selection of bacteria that have resistance genes to heavy metals, biocides, and several drugs.

Impact: The study is the first to show that long-term persistence of heavy metals in the environment may trigger genetic changes and interfere with the microorganism communities that colonize dairy cows. If antibiotic resistance is transferred via milk or meat consumption, it could have substantial implications for human health.

More intensely roasted cocoa beans can help to reduce sugar in chocolate for **health-conscious consumers**.

Problem: **Can healthier chocolate still taste good?**

- Dark chocolate is particularly high in flavonoids, which are considered functional ingredients due to their associated health benefits.
- However, to make chocolate more likeable, it is usually sweetened to mask the cocoa bean's inherent bitterness and astringency.

Findings: Researchers took a novel approach to studying bitterness perception and consumer acceptability of 100 percent chocolate by using human sensory evaluation to study the variation of cocoa-related bitterness.

- The study involved 27 100-percent-chocolate preparations made from cocoa beans roasted at various intensities and 145 people who came to Penn State Sensory Evaluation Center on five consecutive days, evaluating five different samples each day.
- The researchers reported that more intense roasting conditions led to chocolate consumers finding unsweetened chocolate the most acceptable.

Impact: Confection makers who want to develop products containing 100 percent chocolate and no sugar for health-conscious consumers can reduce bitterness and optimize flavor acceptance by roasting cocoa beans longer and at higher temperatures.

ADOBE STOCK

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Competitive Funding: *Professional Manufacturing Confectioners Association*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04624, Accession #1013412*

ADOBE STOCK

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

Understanding how children choose food can help guide parents in **encouraging more nutritious choices**.

Problem: **How can parents help to improve their children's nutrition?**

- Although liking a food plays a primary role in determining what and how much children eat, the relationship between liking and intake of foods and beverages served as a part of a meal is not often reported.

Findings: Researchers conducted an experiment involving 61 children ages 4–6 years to assess the relationship between their liking of foods in a meal and subsequent intake.

- Before being a served a multi-component meal of seven foods (chicken nuggets, ketchup, potato chips, grapes, broccoli, cherry tomatoes, and cookies) and two beverages (fruit punch and milk), the children were asked to rate their liking of each food.
- After the children had eaten as much of the meal as they wanted, the researchers weighed what they ate and compared the results with what the children said they liked and disliked.

Impact: This novel study addressed a common issue of consistency among young children in reporting whether they liked a food or not by also measuring the intake of the foods they rated. The researchers found that rather than just eating what they like, children are more likely to not eat what they dislike.

- With this understanding, intervention programs can be designed to help increase acceptance of highly disliked foods, like vegetables, as well as to encourage children to consume them and to prevent excess plate waste.

Studying behavioral responses to learn how wildlife populations **adapt to rapid changes** in environmental conditions.

Problem: **Can we predict the impact on wildlife populations experiencing quickly changing environmental conditions?**

- The capacity of a species to adapt rapidly is key to its persistence, but linking changes in ecology to the evolution of traits in nature can be difficult without natural replication of the conditions studied.

Findings: Researchers studied the threespine stickleback fish in Iceland's geologically young freshwater lakes. Their exceptional capacity to invade freshwater habitats provided a unique opportunity to compare their reactions with marine fish, which represented an ancestral state for the organism.

- The researchers reported that fish from spring-fed lakes—especially from the highlands where they likely were more diverged from marine fish than lowland fish—reacted fastest to mechano-visual cues and were generally most active. Highland glacial fish showed strong responses to olfactory cues and the greatest plasticity in response to light levels.

Impact: This innovative study takes an important step toward a more global understanding of the complexity and repeatability of behavioral change in novel environments, advancing ecologists' and conservationists' ability to better predict the impact of habitat change on biodiversity at large.

ADOBE STOCK

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Federal and State Appropriations: *USDA NIFA Hatch Project PEN04768, Accession #1026660*

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Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04716, Accession #1020527; Animal Health Project PEN04620, Accession #1011873; Hatch Project PEN04652, Accession #1016243*

Improving the health of honey bees through the discovery of genetic traits for disease tolerance.

Problem: **How can disease and decline of domesticated honey bee colonies be prevented?**

- Selection associated with domestication of honey bees may have decreased their fitness and left them vulnerable to pests and pathogens.

Findings: The researchers partnered with beekeepers to pair 25 feral honey bee colonies across Pennsylvania with a managed colony within a 7-mile radius. Over two years, the team measured winter survival, levels of two viruses and a parasite, and expression of six genes that regulate immunity.

- The team identified two genes that could serve as biomarkers of honey bee health to predict a colony's ability to survive the winter.
- Feral honey bee colonies may have higher tolerance to pathogens than managed bee colonies.

Impact: The findings may help lead to breeding stocks that would enhance survival of managed colonies and decrease colony losses for the beekeeping industry.

- The study was the first to show the association of host–pathogen dynamics with survival of feral colonies.

Improving pollinator habitats can help to **rebuild valuable hardwood species**.

Problem: **How can we better promote the growth and sustainability of premier commercial hardwoods?**

- Black cherry is a unique hardwood in that it requires insect pollination and is unable to produce viable seed from self-pollination.
- Pennsylvania is home to nearly 30 percent of the nation's black cherry trees, used to make high-quality wood products. Over the last 20 years, seedling densities have decreased 60 percent across the Allegheny Plateau.

Findings: Researchers conducted a two-year study in developed, semi-developed, and forested areas in Centre County, Pennsylvania, and in the Allegheny National Forest to evaluate pollinator communities visiting black cherry trees.

- The researchers found andrenid—or miner—bees represented 24 percent of all interactions with black cherry flowers and carried an average of 347 times more black cherry pollen than flies and 18 times more than halictid—or sweat—bees.

Impact: This study highlights the important role of safeguarding the habitat of miner bees, which are also important pollinators of other valuable flowering trees, including apples.

- The findings can help land managers to take steps to attract and support miner bees through practices such as thinning or clearing trees at high density from sunny, well-drained areas.

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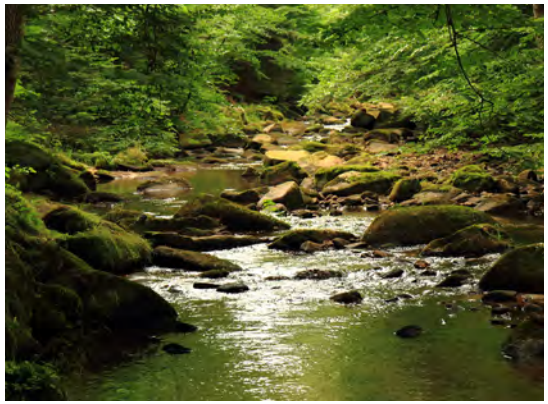
Other Funding: *Wyman's of Maine*

Federal and State Appropriations: *USDA NIFA McIntire-Stennis Project PEN04721, Accession #1020583*



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Other Funding: *Basque Government in Spain*

Studying biodiversity loss in streams can help to **preserve essential ecosystem functions**.

Problem: **How can we preserve detritivore biodiversity in streams?**

- Detritivores are essential organisms that break down and remove dead plant and animal matter, but their populations are dwindling at an alarming rate of up to 10,000 times faster than has occurred through the historic record.
- Decomposition by detritivores is a biological process that is vital to life, releasing essential nutrients like phosphorous and nitrogen that are otherwise unavailable to plants and animals.

Findings: In a global study involving 75 scientists analyzing decomposition in 38 physically similar headwater streams across 23 countries on 6 continents, the researchers quantified the amount of decomposition by detritivores compared to that of microbial organisms alone.

- When detritivores were excluded, simulating extinction, more than 50 percent of decomposition in the streams was lost.
- The study revealed that bacteria and fungi cannot solely decompose and recycle biologically essential materials needed to sustain stream ecosystems.

Impact: The team found that diversity was one of the most dominant predictors of decomposition, which is likely being altered by detritivore extinctions. At highest risk are stream ecosystems in tropical regions where detritivore diversity is already relatively low and some environmental stressors are particularly prevalent.

Enlisting the help of natural predators to curb the spread of harmful insects.

Problem: **How can invasive spotted lanternfly populations be reduced without pesticides?**

- The spotted lanternfly is a destructive pest that feeds on more than 100 species of plants and trees. Because the spotted lanternfly is a nonnative insect, it did not arrive in the U.S. along with its natural enemies to keep its numbers in balance, unlike in its native environment of Asia.

Findings: Researchers conducted field and lab experiments to find species in the U.S. that will prey on spotted lanternflies. They recruited the help of citizen scientists, who provided 1,294 photos and observations of birds, insects, and wildlife eating spotted lanternflies.

- Preliminary findings show that the top bird predators are chickens, cardinals, catbirds, blue jays, and the tufted titmouse rounding out the top five. Among arthropods, the major predators were spiders, followed by preying mantises, yellow jackets, wheelbugs, and ants.

Impact: The findings could help citizens take steps to attract these predators because they will help to control not only spotted lanternflies but other pests as well.

MICHAEL HOUTZ, PENN STATE

Team: *Anne Johnson, Kelli Hoover, Margaret Brittingham, Sara Hermann, Allison Cornell*

Partner: *Penn State Altoona*

Federal and State Appropriations: *USDA NIFA McIntire-Stennis Project PEN04755, Accession #1024129*

ADOBE STOCK

Team: *Erica Smyers, Julie Urban, Andrew Dechaine, Douglas Pfeiffer, Stephen Crawford, Dennis Calvin*

Partners: *Virginia Polytechnic Institute and State University; Penn State Center for Environmental Informatics*

Competitive Funding: *USDA Animal and Plant Health Inspection Service; Pennsylvania Department of Agriculture*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04576, Accession #1004464*

Zeroing in on egg hatch timing **can help control spotted lanternflies**.

Problem: **What can be done to minimize spotted lanternfly populations?**

- The invasive, nonnative spotted lanternfly poses a significant threat to Pennsylvania agriculture, landscapes, and natural ecosystems, particularly with increasing populations of recently hatched nymphs feeding on various host plants important to the state's economy.

Findings: Researchers investigated the probability of egg hatch based on the weather conditions and temperature.

- In controlled lab studies, the team evaluated sets of 30 individual egg masses at 5 constant temperatures. During field studies, they observed 112 marked egg masses throughout May and June for the emergence of first-instar nymphs.
- Egg developmental rate increased as the constant temperature increased. The findings led to the development of an online tool to predict egg hatch based on weather conditions and location.

Impact: Predicting when spotted lanternfly eggs will hatch can help with control tactics to reduce nymphs.

- Citizens and the agricultural industry can use the tool to make decisions about timing and management strategies. Government agencies, university researchers, and extension professionals can use it for surveillance efforts.

Discovery of coronavirus infections in white-tailed deer can help predict or prevent the **emergence of novel variants**.

Problem: **Can we prevent potential spillback of SARS-CoV-2 from wild animals to humans?**

- The global spread of SARS-CoV-2 (the virus that causes COVID-19 in humans) poses risks for spillover transmission to nonhuman hosts, which could in turn act as reservoirs for the virus, and potentially "spillback" to human hosts.

Findings: A team of researchers reported the first direct evidence of SARS-CoV-2 virus in any free-living species when they discovered that more than 80 percent of the white-tailed deer sampled in different parts of Iowa between December 2020 and January 2021 tested positive for the virus.

- The team examined nearly 300 samples collected as a part of a routine health surveillance program in Iowa, finding several different SARS-CoV-2 lineages circulating within geographically confined herds. This research suggested the occurrence of multiple independent spillover events from humans to deer, followed by local deer-to-deer transmission.

Impact: This discovery highlights the urgent need to support and sustain a robust and proactive "one health" approach that includes surveillance programs to monitor the spread of SARS-CoV-2 within deer and other susceptible wildlife species in the battle against the long-term persistence and evolution of this coronavirus.

- A better understanding of the ecology, molecular evolution, and spread of SARS-CoV-2 will help scientists and public health officials to predict and even prevent the emergence of future infectious diseases with pandemic and spillover potential.

ADOBE STOCK

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Partners: *Iowa Department of Natural Resources (DNR); Penn State Eberly College of Sciences; Iowa State University; Penn State College of Engineering; University of Cambridge; Weill Cornell Medical College; Argonne National Laboratory; Houston Methodist Research Institute; Houston Methodist Hospital*

Competitive Funding: *USDA NIFA (AFRI); US Fish and Wildlife Service (Wildlife and Sport Fish Restoration Program); Penn State Huck Institutes of the Life Sciences; Iowa DNR (Fish and Game Protection Fund); Houston Methodist Academic Institute (Infectious Diseases Fund); National Institutes of Health; NSF (Ecology and Evolution of Infectious Diseases Program)*

Federal and State Appropriations:
USDA NIFA Hatch Project PEN04748, Accession #1023391

ADOBE STOCK

Team: *Heather Preisendanz, Andrew Read, Tom Richard, Shirley Clark, Matt Jones, Justin Silverman, Michael Shreve, David Swisher, Cory Miller, Kathryn Hayden, Olivia Mroczko*

Partners: *Penn State Huck Institutes of the Life Sciences; Penn State Office of the Physical Plant; University Area Joint Authority; Penn State College of Information Sciences and Technology; USDA Agricultural Research Service Pasture Systems & Watershed Management Research Unit; Penn State Institutes of Energy and the Environment; Pennsylvania Department of Health*

Other Funding: *Penn State Office of the Provost; Penn State College of Agricultural Sciences Institute for Sustainable Agricultural, Food, and Environmental Sciences (SAFES); Penn State Huck Institutes of the Life Sciences*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Projects PEN04726 and PEN04671, Accession #1020769 and #1017582*

Using surveillance tactics to **alert and prevent virus spread**.

Problem: **How can communities better anticipate and mitigate the spread of COVID-19?**

Findings: Research has shown that fragments of the RNA from SARS-CoV-2 is present in human waste. As a result, sampling wastewater for the virus has the potential to give an overall snapshot of its prevalence in a community.

- The team monitored existing flow meters in several manholes at the University Park campus to determine the volume of water passing through and used devices programmed to collect water samples every 5 minutes for 24 hours in the manholes as well as from the treatment plants on campus and in the surrounding community.
- A technique called polymerase chain reaction (PCR) amplified the genetic material in the samples to the level of detection and recorded the concentration of virus fragments per milliliter of water to track the rate of increase or decrease in the concentration over time.

Impact: Wastewater monitoring provides a cost-effective way of monitoring for things that are rare; for example, polio is monitored in this way throughout the world.

- Adding this surveillance tool helps to enhance monitoring for COVID-19 and could enable leaders to take swift actions to minimize the virus's spread to help protect the health and safety of the community.

New test allows for **rapid and cost-effective diagnosis** of devastating citrus disease.

Problem: **What can be done to prevent crop losses due to citrus greening?**

- Since 2005, *Candidatus Liberibacter asiaticus* (CLas)—a devastating and broadly distributed bacterial pathogen that causes citrus greening or Huanglongbing (HLB)—has reduced Florida's orange crop production by more than 70 percent and has been detected in Texas, California, Georgia, and Louisiana.
- The best hope of reducing the spread of citrus greening is to eliminate diseased trees quickly, but current detection methods often fail, especially in asymptomatic tissue. Infected trees can act as a disease reservoir for months or years before showing visible symptoms

Findings: Researchers used CRISPR/Cas technology, a powerful gene-editing technology that has been recently adapted as a molecular diagnostic tool, to develop a highly specific and sensitive assay to detect the presence of CLas nucleic acids across different infected citrus and insect vector samples.

Impact: Early detection technology for disease diagnosis and quarantine of infected crops and insect vectors can help to minimize crop loss and prevent transmission into disease-free, citrus-growing regions.

- The CRISPR/Cas method provides a sensitivity detection level 100 to 1,000 times greater than the current diagnostic tests commonly used. The assay used for this test was shown to be compatible with lateral flow technology, similar in concept to home pregnancy tests, holding promise for providing rapid and economical testing for HLB in the field.

ADOBE STOCK

Team: *Yinong Yang, Matthew S. Wheatley, Qin Wang, Yong Ping Duan*

Partners: *USDA Agricultural Research Service, U.S. Horticultural Research Laboratory*

Competitive Funding: *USDA Animal and Plant Health Inspection Service (APHIS)*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04659, Accession #1016432*

ADOBE STOCK

Team: *Suresh V. Kuchipudi, Meera Surendran Nair, Michele Yon, Abhinay Gontu, Ruth H. Nissly, Rhiannon Barry, Denver Greenawalt, Traci Pierre, Lingling Li, Nagaraja Thirumalapura, Deepanker Tewari, Bhushan Jayarao*

Partner: *Pennsylvania Veterinary Laboratory*

Competitive Funding: *Pennsylvania Soybean Board; Pennsylvania Department of Agriculture; USDA NIFA*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04748, Accession #1023391*

Prompt detection of infectious animal diseases can help **prevent economic losses and ensure food security**.

Problem: **How can we intervene more quickly before animal diseases spread?**

- A swine bacterial pathogen, *Streptococcus equi subspecies zooepidemicus* or "Strep zoo," is difficult to detect with conventional methods because virulent strains show only minor genetic differences from bacteria commonly found in healthy pigs and other animals.
- Outbreaks that go undiagnosed quickly have the potential to spread and cause devastating impacts on animal agriculture.

Findings: Researchers used cutting-edge tools, including next-generation sequencing, to study bacterial isolates from a lethal Pennsylvania Strep zoo outbreak in pigs.

- The team developed a new polymerase chain reaction (PCR) diagnostic assay that distinguished between avirulent strains of Strep zoo and other pathogens associated with swine respiratory disease and the virulent strain.

Impact: This novel assay, which can return results in less than four hours, provides a practical solution to the previously unsolved problem of diagnosing this severe disease in swine herds.

- The reliability of this diagnostic tool means that it can be used to investigate the natural infection of other susceptible animals and to prevent zoonotic risk.

Learning how to support soil **microbiomes for crop health and yield**.

Problem: **How can soil quality be sustained under intensive, repeated use?**

- Although high tunnels can extend the growing season, the quality of the soil under them tends to degrade over time, and crop disease can increase.
- Growers often use chemical fumigation or other soil-sterilizing approaches to kill disease-causing microbes, which can wipe out beneficial microbes essential to plants.

Findings: Researchers looked at how high soil salinity and high soil nitrogen concentrations altered soil microbiome development. They buried small nylon mesh bags containing unsterilized "source" soil in sterilized "recipient" soil and left them to incubate for seven weeks. Recipient soils were amended with salt, nitrogen, both, or neither to determine whether these properties impacted the microbial communities' composition in the recipient soil.

- They found that higher soil salinity and higher soil nitrogen delayed the re-establishment of a diverse soil microbiome.

Impact: The results of this study help to untangle the many factors impacting the recolonization of microbial communities that benefit crop production. The team's findings are laying the groundwork for the development of guidelines that will aid farmers in improving soil fertility, and by extension, crop health and yield.

GORDON HARKINS, PENN STATE

Team: *Laura Kaminsky, Paul Esker, Terrence Bell*

Competitive Funding: *USDA NIFA (Organic Transitions Program); NSF (Graduate Research Fellowship)*

Federal and State Appropriations: *USDA NIFA Hatch Projects PEN04651 and PEN04660, Accession #1016233 and #1016474*

JOSEPH AMSILI

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Partner: *Penn State Russell E. Larson Agricultural Research Center*

Competitive Funding: *USDA NIFA (OREI)*

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

Cover crop roots can help growers reap **environmental and financial benefits**.

Problem: **How can cover crops be enhanced to improve ecosystem services?**

- Cover crops are used to increase the quantity of organic carbon returned to the soil between cash crops such as corn, to limit erosion, and to add soil nitrogen.

Findings: In a recent study as a part of a continuous experiment conducted since 2011, researchers focused on cover crop roots, known to be essential in increasing soil carbon levels. They evaluated cover crop treatments including monocultures of triticale, canola, and crimson clover as well as a five-species mixture dominated by those three species to learn about root-trait variation among species, and how that variation impacts mixture design.

- By measuring the ratio of root biomass to aboveground biomass, or the root-to-shoot ratio, and relating that to the amount of nitrogen in the plants, the team could determine how these parameters differed between cover crop treatments. They found that the mixtures increased total carbon input and promoted higher carbon inputs from corn crop residues.

Impact: This study improves understanding of the linkages between root traits and the ecosystem services that cover crops provide, giving clearer insight into how to design cover crop mixtures with complementary root traits that can deliver added boosts to cash crops that follow.

Breeding novel corn lines to provide powerful antioxidants that **help protect against intestinal disease**.

Problem: **Can crops be bred to provide safe and natural ways to improve animal health?**

- With half of the chickens raised in the U.S. without antibiotics, amounting to nearly 4 billion chickens, there is a significant need for alternatives to treat illnesses such as necrotic enteritis, which afflicts mostly young broiler chickens and leads to massive economic losses.

Findings: Plant and animal scientists fed a novel, hybrid line of high-flavonoid corn (PennHFD) developed at Penn State to chickens with necrotic enteritis and compared the effects to chickens fed a diet based on commercially available corn.

- In this study, the birds fed a PennHFD-based diet had a 48 percent lower incidence of intestinal lesions, higher body weight gain, a better feed-conversion ratio, and a 23 percent lower mortality rate than the chicks fed on the control diet.

Impact: This discovery paves the way for future research to understand the dosage effect of PennHFD corn in chicken diets and better understand the anti-inflammatory and antibacterial properties of the corn's increased flavonoids in controlling the disease.

- This potential therapy could help to reduce the $6 billion loss in productivity and treatment or prevention costs every year worldwide due to necrotic enteritis.

ADOBE STOCK

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Other Funding: *Penn State College of Agricultural Sciences Motivating Innovation and Seeding Technologies Program; Penn State College of Agricultural Sciences Research Applications for INnovation Program*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04780, Accession # 7000699; USDA NIFA Smith-Lever Project PEN08501*

ADOBE STOCK

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Competitive Funding: *NIH (National Center for Complementary & Integrative Health); USDA NIFA (AFRI)*

Other Funding: *Penn State College of Agricultural Sciences*

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

Substituting dietary cocoa powder for high-calorie snacks may **provide positive health implications** for people.

Problem: **Can dietary interventions help to reduce increasingly common chronic diseases?**

» Nonalcohol-related fatty liver disease affects about one-quarter of the U.S. population, and can occasionally progress into severe diseases, such as cirrhosis of the liver. The cause of the disease is commonly associated with human obesity.

Findings: For this study, researchers examined changes in fatty liver disease, markers of oxidative stress, antioxidant response, and cell damage in high-fat-fed obese mice treated with a diet supplemented with cocoa powder.

» The scientists reported that cocoa-treated mice gained weight at a 21 percent lower rate and had smaller spleen weights—indicating less inflammation—than the high-fat-fed control mice. At the end of the study, mice fed the cocoa-powder-supplemented diet had 28 percent less fat in their livers than the control mice.

Impact: Given the high proportion of people in the U.S. and other parts of the world with obesity, there is a need to develop potentially effective dietary interventions rather than just preventive agents for conditions like fatty liver disease, which often develop without causing any symptoms.

» While the mechanisms by which cocoa imparts health benefits are not well understood, this study and others show that extracts from cocoa and some of the chemicals in cocoa powder can inhibit the enzymes that are responsible for digesting dietary fats and carbohydrates.

Supporting the growth of female-owned farms.

Problem: **What can be done to address the needs of female farmers?**

- The number of farms operated by women has risen over the past two decades.

Findings: Researchers studied the importance and unique characteristics of U.S. female farmers to identify the aspects of the local economy and agriculture most strongly associated with female-owned farms.

- The researchers identified 10 economic variables, including unemployment, nonfarm wages, availability of childcare, and the rate of female participation in the labor force. They also examined the total number of farms, average farm size and annual sales, average farmer age, and the types of farm activities carried out.
- Their findings showed that female-owned farms in the U.S. are more common in areas that are closer to urban markets, engage in agritourism activities, and offer greater access to childcare. They also uncovered that direct-to-consumer sales are more prevalent in counties with more female-owned farms.

Impact: Without full knowledge of female farm-operators' decision making, agricultural service providers have made assumptions about the type of information and products useful to them.

- By understanding how female-owned farms are unique, we can start to learn how best to serve and grow this population.

ADOBE STOCK

Team: *Claudia Schmidt, Stephan Goetz, Zheng Tian*

Partner: *Northeast Regional Center for Rural Development*

Competitive Funding: *USDA NIFA (Rural Development Centers)*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04633, Accession #1014522*

Team: *Azlan Zahid, Md Sultan Mahmud, Long He, Daeun Choi, Paul Heinemann, James Schupp*

Partner: *Penn State Fruit Research and Extension Center*

Competitive Funding: *USDA NIFA (NE SARE)*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04547, Accession #1001036*

Novel pruning system can **provide automated, cost-effective solutions** to ease challenges facing tree-fruit growers.

Problem: **What can be done to help tree-fruit growers struggling with increasing labor shortages and high associated costs?**

- In the U.S., apples are one of the most valuable specialty crops, contributing about $3 billion to the tree-fruit industry.
- Pruning apple trees, necessary for profitable quality and quantity, requires about 31 working hours of skilled manual labor per acre, comprising about 20 percent of total pre-harvest production costs.

Findings: Researchers designed an automated, computerized pruning system for modern apple orchards, integrating a pruning compact robotic arm with two rotational joints and three linear joints to be able to operate in tight spaces and orient itself at almost all possible angles to reach any branch.

- Field tests assessed the performance of the prototype, finding that the cutting mechanism, or "end-effector," successfully cut branches up to an inch in diameter and at a wide range of orientations.

Impact: Automated solutions such as this innovative end-effector can provide growers with cost-effective alternatives when labor pools are limited. The introduction of robotics into agriculture reduces the burden of repetitive manual processes and opens new career pathways for agricultural workers.

Understanding the impacts of climate change can help vulnerable communities **to build resilience**.

Problem: **How can we counteract food-supply issues exacerbated by climate change?**

- In countries like Nepal, where the economy is heavily dependent on agriculture, predictable monsoon seasons are critical to ensuring an adequate supply of nutritious food.
- With climate change, Nepal is projected to experience increased monsoon rainfall variability, including heavy rain events that threaten to worsen the high rates of poverty and food insecurity.

Findings: A team of scientists examined integrated data from the 2016 Nepal Demographic and Health Survey with earthquake-intensity data from the U.S. Geological Survey and monsoon rainfall data from the Climate-Weather Research and Forecasting Model.

- They found that more rainfall was positively linked with food insecurity in earthquake-affected regions where the increased precipitation can cause landslides that damage roads, disrupt the distribution of food aid, and destroy agricultural land and assets.

Impact: The findings have significant implications for Nepal—one of the most disaster-prone countries in the world—and for countries around the globe, given the increasing frequency and severity of extreme weather events due to climate change.

- The knowledge gained from this study can serve as a platform to create adaptation strategies that will improve global health and promote sustainable development.
- With continued research on the social impacts of compound environmental shocks, scientists can better identify vulnerable groups and more effectively assist communities in recovery and building resilience.

ADOBE STOCK

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Competitive Funding: *National Science Foundation (Innovations at the Nexus of Food, Energy and Water Systems)*

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

ADOBE STOCK

Team: *Stephan Goetz, Connor Heaton, Muhammad Imran, Yuxuan Pan, Zheng Tian, Claudia Schmidt, Umair Qazi, Ferda Ofli, Prasenjit Mitra*

Partners: *Northeast Regional Center for Rural Development; Penn State College of Information Sciences and Technology; Hamad Bin Khalifa University, Qatar*

Competitive Funding: *USDA NIFA (Rural Development Centers); Penn State College of Agricultural Sciences Institute for Sustainable Agricultural, Food, and Environmental Science (SAFES)*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04633, Accession #1014522*

Harnessing social media to **identify food insecurity problems**.

Problem: **Can we identify where food-security interventions are most needed when supply chains are disrupted?**

- Global food supplies can be compromised by major shocks to supply chains caused by war, natural disasters, or health crises, such as the onset of the COVID-19 pandemic.
- Surveys are one way to assess disruptions to food security, but they tend to be costly with delayed results.

Findings: Researchers analyzed Twitter posts in real-time to understand how people actually felt about their food situation and provide insights into user behavior, emotional state, and sentiment during the COVID-19 pandemic. To carry out the study, they used a dataset known as GeoCoV19, which contains hundreds of millions of pandemic-related tweets in multiple languages from all over the world.

- Using artificial intelligence and natural-language processing, they were able to separate tweets expressing concerns about food supply from those expressing relief or contentment.
- Food security-related tweets that expressed anger, disgust, or fear were strongly correlated with actual food insufficiency in certain U.S. states early in the COVID-19 pandemic.

Impact: These findings can potentially be used to develop a low-cost early warning system for planners, supply chain managers, and policymakers to detect when and where localized food security problems emerge in real-time.

Growing the right crop in the right place within an impaired watershed can achieve **significant water-quality improvements**.

Problem: **What can be done to amplify efforts to restore the troubled Chesapeake Bay?**

- A significant source of nutrient and sediment pollution in the bay is a result of surface water runoff from agricultural fields in the watershed.

Findings: Researchers deployed a powerful computer program called the Soil and Water Assessment Tool to model crop growth and losses of nutrients and sediment for an eight-year period, developing an innovative algorithm to spatially reallocate crop rotations within existing agricultural land of the Conewago Creek watershed.

- The simulation reallocated hay onto landscapes most vulnerable to erosion and nutrient loss, and row crops such as corn-soybean rotations were reallocated onto less vulnerable areas.
- The team calculated a 15 percent reduction in total nitrogen losses, 14 percent reduction in total phosphorous losses, and 39 percent reduction in sediment losses at an average annual scale across the watershed.

Impact: The results of this study suggest that redistributing crop rotations within the bay watershed did not impact the yield and may help farmers and policymakers to achieve substantial water-quality benefits with sharp reductions in pollution.

ADOBE STOCK

Team: *Fei Jiang, Patrick Drohan, Cibin Raj, Heather Preisendanz, Charles White, Tamie Veith*

Partners: *USDA Agricultural Research Service Pasture Systems & Watershed Management Research Unit; Penn State Institute for Computational and Data Sciences*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Projects PEN04574, PEN04629, and PEN04573, Accession # 1004448, #1014132, and #1004449*

ADOBE STOCK

Team: *Heather Preisendanz, Tamie Veith, Qian Zhang, James Shortle*

Partners: *USDA Agricultural Research Service Pasture Systems & Watershed Management Research Unit; Penn State Institutes of Energy and the Environment; University of Maryland Center for Environmental Science, U.S. Environmental Protection Agency Chesapeake Bay Research Program*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Projects PEN04574, Accession # 1004448*

Targeting critical moments across impaired watersheds can help achieve water-quality-restoration goals.

Problem: **How can approaches be improved to meet load-reduction goals more efficiently for the Chesapeake Bay watershed?**

- With increasing intensity of severe storms causing high-flow events, a focus on "hot spots" does not account for a small percentage of locations and events that contribute to the vast majority of total annual pollution loads.

Findings: Researchers analyzed eight years of data from 108 sites in an established monitoring network, looking at daily-scale records of flow and corresponding loads of total nitrogen, total phosphorous, and total suspended sediment at each gauging station.

- Their innovative application of a formula normally used in economics to quantify inequity in wealth distribution allowed them to measure the degree of inequality of loads and identify periods of time and corresponding flow conditions to target.

Impact: The study's conclusions propose a critical shift in approaches to meeting load-reduction goals from "everything, everywhere, all the time" to "finding the right solutions in the right places that work at the right time," allowing watershed planners and managers to develop low- and high-flow targets for nutrient and sediment loads specific to each watershed in the bay's 64,000-square-mile basin.

Partnering within the University technology transfer ecosystem and with industry collaborators to **bring innovative, new technologies to society**.

The Entrepreneurship and Innovation (E&I) team brings industry and economic development experience to the College of Agricultural Sciences, helping to build bridges between innovators and the resources necessary for the successful transfer of their technologies to the marketplace. Many inventors are navigating intellectual property protection and commercialization for the first time, with no training or prior experience. The E&I team is providing invaluable guidance in helping to transition the technologies generated through research into products that improve lives.

Resources to Bridge the Gap

The proverbial "valley of death"–the gap between research funding and commercial investment–lies between the inventors and those who may benefit from their inventions. The E&I team helps to bridge this gap with government, philanthropic, college, and university programs and funding. Ultimately, these efforts are intended to stimulate economic development through the transfer of technologies to the marketplace.

Sustaining the Pipeline

Tomorrow's innovations rely on a robust pipeline of new talent, ready to engage with an entrepreneurial mindset and contribute their innovations to the benefit of society. E&I programs are designed to facilitate and develop tomorrow's innovators with outreach, education, and mentoring efforts.

Learn more about E&I at **agsci.psu.edu/entrepreneur**

ADOBE STOCK

E&I Programs

- **Research Applications for INnovation (RAIN) program**: funding to support research commercialization
- **Charles R. and Ellen M. Krueger RAIN Endowment**: support for a graduate student whose efforts are focused on research commercialization
- **Motivating Innovation and Seeding Technologies (MIST) program**: support for early-stage intellectual property development efforts
- **Practicum in Innovation and Critical Thinking**: a course that pairs graduate students with industry mentoring opportunities, helping students build professional networks as well as strengthening the relationship between Penn State and industry
- **Harbaugh Undergraduate Research Assistantship (HURA)**: opportunity for talented undergraduate students to work alongside faculty researchers on projects with commercial potential
- **Ag Springboard Competition**: a student business pitch competition with intensive mentoring from E&I faculty

ADOBE STOCK

SAFES Critical Issue Initiatives

- Agricultural Sustainability in Urbanized Landscapes
- Bioeconomy Solutions
- Contaminants of Emerging Concern
- Food Choice and Health
- Managing Earth's Critical Zone
- Precision Biodiversity
- Regenerative and Climate-Smart Landscapes
- Resilient Coupled Human-Earth Systems
- Stakeholder Engagement Science and Practice
- Transformative Water Quality Strategies

Amplifying expertise through **purposeful engagement and collaboration** within the broader Penn State community.

The Institute for Sustainable Agricultural, Food, and Environmental Science (SAFES) is a transdisciplinary institute housed within the College of Agricultural Sciences. SAFES employs 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 is organized into three integrated programmatic areas of Research, Education, and Partnerships & Engagement.

Research at the Epicenter of Complex Challenges

The Critical Issue Initiatives provide a framework for the SAFES collaborative community of researchers, students, and stakeholders to foster a culture and portfolio of transdisciplinary projects that integrate across research disciplines. Working at the complex intersections of food, ecosystems, water, and climate, these organized areas of expertise strengthen the University's capacity to effectively respond with state-of-the-art knowledge and solutions to emergent problems.

- Since 2020, more than 125 faculty across six colleges at University Park and four Commonwealth campuses have formed ten Critical Issue Initiatives.

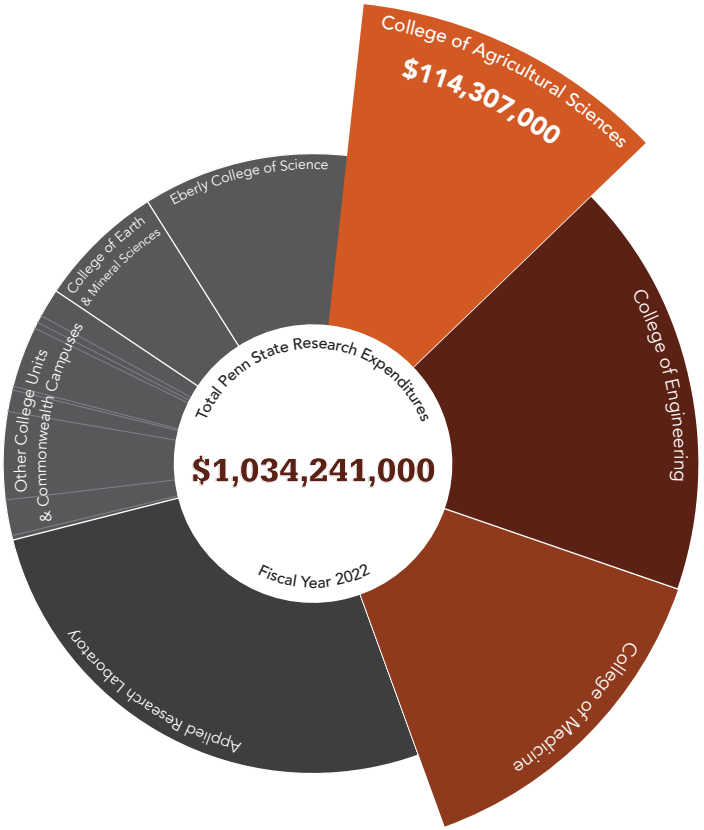
Learn more about SAFES at **agsci.psu.edu/safes**

Research conducted in the College of Agricultural Sciences addresses both near- and long-term problems by investigating important fundamental, basic research questions that **ensure a continuum from discovery to delivery**.

- 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 and that address critical issues important to agriculture and the environment.
- Graduate programs produce the next generation of scientists and educators to advance agricultural sciences and discover innovative solutions to future global challenges.

DATA FROM THE OFFICE FOR RESEARCH AND GRADUATE EDUCATION FOR FISCAL YEAR 2022; PUBLICATION DATA FROM CALENDAR YEAR 2021

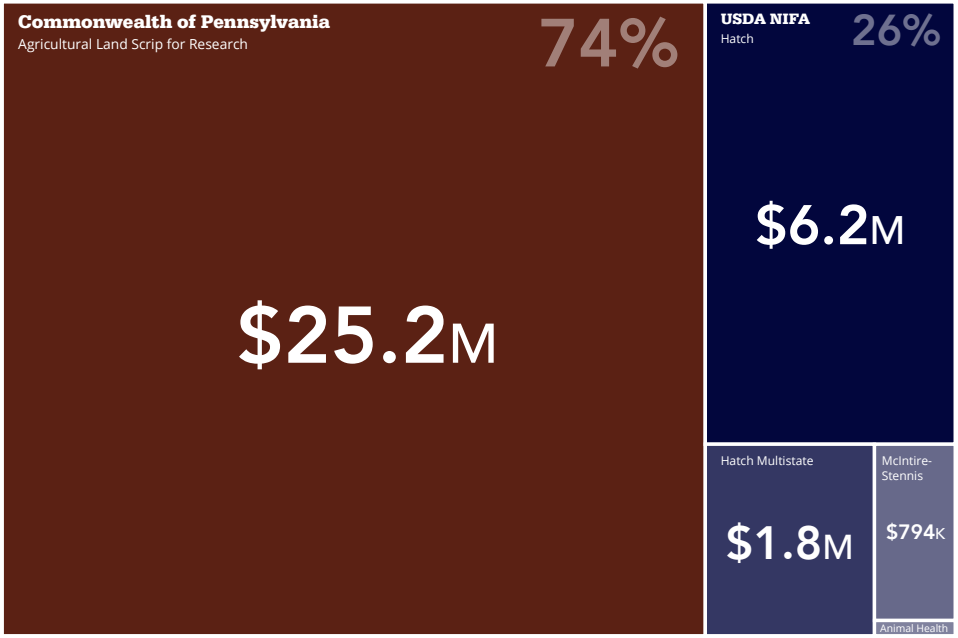
As one of more than 20 units contributing to Penn State's research expenditures, the College of Agricultural Sciences has consistently been among **the top three highest-performing college units** for the past 10 years.



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

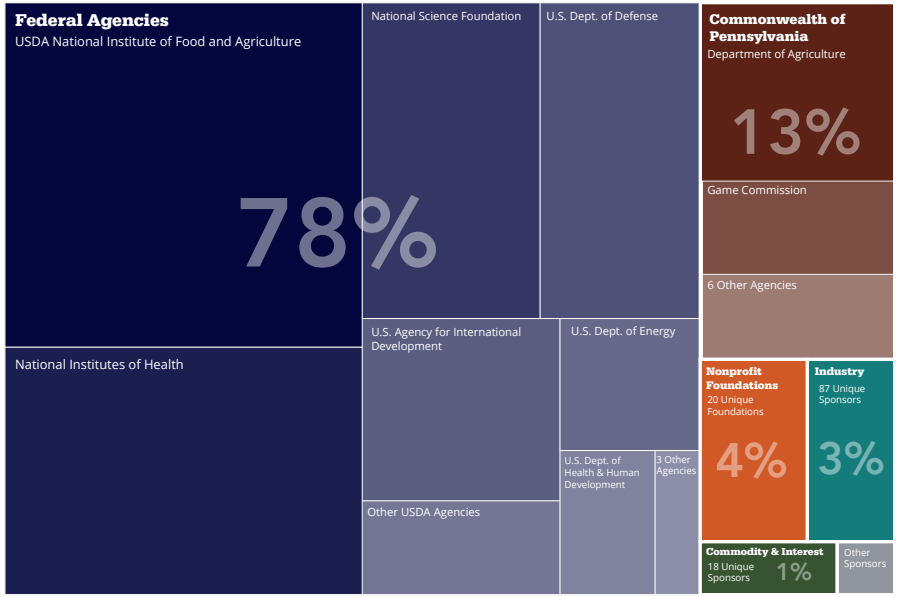
The College of Agricultural Sciences is the Commonwealth's **steward of federal and state appropriations** to support agricultural research.

- Federal- and state-appropriated funds managed through the Pennsylvania Agricultural Experiment Station provide essential base funding to maintain expertise and program support in order to respond quickly to issues that emerge.
- The passage of the Hatch Act in 1887 established federal support for the nation's network of Agricultural Experiment Stations to conduct agricultural research at land-grant universities.
- The Commonwealth of Pennsylvania has exceeded the required match for federal appropriations by at least two-and-a-half times since 2008, accounting for 74 percent of the total amount of government capacity funds for agricultural research.



Researchers in the College of Agricultural Sciences also **support their discoveries and innovations through extramural grants**.

- Research, outreach, and instruction in the College of Agricultural Sciences was supported by **a total of $135.4 million** in extramural grants leveraging the critical capacity of expertise and facilities supported by appropriations that help to make them more competitive.
  - This banner year marks a total **increase of 16 percent** over the average of the last four years.
- Research awards accounted for more than two-thirds of this funding for the college's activities. Grants awarded from **federal agencies accounted for approximately 78 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.



SPONSORS OF COMPETITIVE GRANTS FOR FISCL YEAR 2022

College of Agricultural Sciences' investigators are leading large interdisciplinary teams to **propel research inquiry and discovery** in pursuit of tomorrow's solutions.

Current and Emerging Threats to Crops Innovation Lab (CETC IL)

A multi-institute team led by Penn State and funded by the U.S. Agency for International Development (USAID) was awarded up to $39 million total over five years to establish a Feed the Future Innovation Lab, a program supported by the U.S. government to combat global hunger and poverty. This Innovation Lab will serve as a venue for a broad coalition of experts from around the world to collaborate on novel approaches to monitor, predict, and combat current and emerging threats to crops. The team will focus its efforts in West Africa, East/Southern Africa, South/Southeast Asia, and Central America. (Principal Investigator: David Hughes, Department of Entomology)

Understanding Multi-Stressor and Multi-Scale Drivers of Feedbacks, Cascading Failures, and Risk Management Pathways within Complex MSD Systems

The U.S. Department of Energy awarded a $17 million, five-year cooperative research agreement to a multi-institutional research team led by Penn State. This award supports the continued work of the Program on Coupled Human-Earth Systems (PCHES) to develop new, state-of-the-art, integrated Multi-sector Dynamics (MSD) modeling frameworks to understand how interconnected systems are exposed to natural hazards that create vulnerabilities and risks for society and how societies respond and adapt to these risks. (Principal Investigator: Karen Fisher-Vanden, Department of Agricultural Economics, Sociology, and Education)

An Integrated Approach to Address the Labor Shortage on Mushroom Farms Through Smart Agriculture

A team of plant pathologists, agricultural and biological engineers, agricultural economists, and information technologists led by Penn State was awarded nearly $4 million by the USDA NIFA Specialty Crop Initiative. This grant will support continued work to improve manual harvesting speed by adjusting production practices, reducing the dependency on manual labor through the development of automated harvesting and packaging machines, and assessing the economic impacts of the proposed technologies. (Principal Investigator: John Pecchia, Department of Plant Pathology and Environmental Microbiology)

Anaerobic Soil Disinfestation for Enhancing and Advancing the Sustainability of Organic Specialty Crop Production Systems (ASD-EASY Organic)

A $3 million grant from the USDA NIFA Organic Agriculture Research and Extension Initiative will support a large, multi-institutional team led by Penn State to work towards preserving soil health and enhancing the sustainability of organic horticulture using anaerobic soil disinfestation (ASD). The project will include coordinated research and on-farm trials aimed at optimizing and integrating ASD into organic vegetable and strawberry cropping systems in Florida and Pennsylvania. (Principal Investigator: Francesco Di Gioia, Department of Plant Science)

PennState
College of Agricultural Sciences

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

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

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Where trade names appear, no discrimination is intended, and no endorsement by the Penn State College of Agricultural Sciences is implied.

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