

Pennsylvania (Penn State University Park) Annual Report - FY2022

Contributing Organizations

Penn State University Park

Directors

Blair Siegfried Signed

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Executive Summary

Overview

Faculty of the College of Agricultural Sciences at Penn State employ a collaborative, interdisciplinary approach to address complex, real-world challenges. From improving human health to ensuring food security, protecting the environment, working toward renewable energy sources, strengthening our communities, and more, we are conducting research and extension outreach that transcends scientific disciplines to arrive at solutions.

College of Ag researchers and Extension associates provide comprehensive support to the residents of Pennsylvania through the activities of the Pennsylvania Agricultural Experiment Station (AES) and Penn State Extension (PSE). We are committed to excellence in research, educating the next generation of agricultural professionals and citizens, and promoting life-long learning among the citizens of Pennsylvania.

The College of Agricultural Sciences is also a world leader in cross-disciplinary research, amplified by partnerships across Penn State and the international science community. Our reach is global but rooted in Pennsylvania.

Our faculty and staff, supported by federal base funding, effectively leverage this investment against many other funding sources to conduct programs of the highest caliber. We receive robust support from partners within the University and in government, business, and other sectors to bring ideas to commercial reality. We work closely with industry to ensure that our research aligns with on-the-ground needs.

Discovery is only the beginning of our work. We extend our research beyond the University and apply it to solve real problems. Penn State College of Agricultural Sciences research and Extension teams shorten the distance between discovery and impact to make life better. Extension equips people with the knowledge and confidence to tackle challenges head on. We are always seeking new and better ways to communicate our science-based programs to new audiences.

Our College's mission is clear: "The mission of the College of Agricultural Sciences is to discover, integrate, translate, and disseminate knowledge to enhance the food and agricultural system, natural resources and environmental stewardship, and economic and social well-being, thereby improving the lives of people in Pennsylvania, the nation, and the world."

Evolving outlook on the future of agriculture

Agriculture in Pennsylvania and around the world faces challenges of rising energy costs, weather extremes, an expanding human population, environmental degradation, loss of biodiversity, labor shortages, and armed conflict. To help meet these challenges, we developed a conceptual framework based on the science of agricultural sustainability—defined as the integration of natural and social sciences to inform practice and policy for productive, working landscapes, healthy watersheds, and resilient economies. This innovative approach to agricultural research, engagement, and education centers on the impacts and synergies of contiguous rural and urban landscapes. From forests to crops to animal facilities, the location of economically significant agricultural systems in Pennsylvania adjacent to and sometimes within highly populated regions creates distinct challenges and opportunities for the integration of natural and social sciences to inform practice and policy.

A primary component of AES and PSE work in our College is built on the three integrated pillars of intensification, resilience, and regeneration of agricultural landscapes as solutions to some of the most vexing problems confronting Pennsylvania and similar mosaic landscapes worldwide. With these challenges and opportunities in mind, we holistically and comprehensively address these critical issues:

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

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

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

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

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

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

Our faculty's proficiencies range in scale from sub-cellular to global. We are engineering web-based platforms to ease the production of robust engineered organisms that can help provide sustainable, clean energy sources and pharmaceuticals. We are tackling existential crises such as transforming the agricultural industry to meet the challenges of the coming climate. Our team addresses the health and welfare of Pennsylvanians, from the newest infants, to youth and young adults, to senior citizens and grandparents raising their grandchildren. We look to build resilient communities by strengthening community organizations and individuals and helping to grow new farm businesses. We seek solutions that are economically viable, socially acceptable, and equitable.

Critical Issue: Advancing Agricultural and Food Systems

Below we highlight some of the noteworthy research and extension efforts from this critical issue this past year, *in addition to the key results featured in this report.*

- An international, multidisciplinary team including a Penn State entomologist conducted a review of the scientific literature and concluded that systemic insecticides such as neonicotinoids can contaminate honeydew, the excretion product of sap-sucking insects such as aphids, mealybugs, whiteflies, and psyllids. Honeydew is an important food source for beneficial insects in agroecosystems, which makes this a serious concern, particularly in large-acreage crops that are commonly treated with these products.
- Penn State Extension provides crucial information on food sustainability to people around the world. The Penn State Mushroom Research Center and extension associates helped a woman in Malawi, East Africa, turn a hobby of growing oyster mushrooms in her backyard into a small business supplying hotels and restaurants. The parties were connected by the U.S. Agency for International Development, and the woman has since received a \$40,000 grant from the United Nations Development Programme to expand her operation.

In a separate effort Penn State mushroom faculty collaborated with Virginia Cooperative Extension to offer a webinar covering different mushroom varieties and the supplies and equipment needed to grow at home. Besides 116 people from nine U.S. states in attendance, 14 southern Cameroonian refugees in Nigeria also watched because they were interested in growing specialty mushrooms to start making a living in Nigeria.

- Here in Pennsylvania, Extension is continuing to support the AgrAbility for Pennsylvanians program, which provides services and support to help farmers and other agricultural workers with a disability or long-term health condition continue to work in production agriculture. The program will enhance

education and outreach to underserved populations in agriculture, including women, veterans, Amish, urban farmers, and ethnically diverse farmers. The addition of mental health and stress resources and support, and continuing education for healthcare professionals about health challenges for farmers, are also critical components.

- The Field and Forage Crops research and extension team is tracking the spread of tar spot, a corn disease first found in Pennsylvania in late 2020. There have been no reports of yield loss due to tar spot in the areas affected, and the team is advising growers to scout regularly and to spray only if it is likely to be economically beneficial to do so.

Critical Issue: Building Community Resilience and Capacity

Below we highlight some of the noteworthy research and extension efforts from this critical issue this past year, *in addition to the key results featured in this report.*

- A Penn State rural sociologist examined the health and safety conditions in farmworker housing on Pennsylvania seasonal farm labor camps. The findings informed policy recommendations to the Pennsylvania Department of Agriculture and brought information to farm employers on trends in violations of housing standards and for improving the farmworker housing inspection process.
- An Extension-focused team studied the role of extension in U.S. agritourism development through two state case studies: Vermont and California. They identified critical elements necessary to build a statewide agritourism program and made recommendations for growing the role of extension in agritourism.
- Collaborators in agricultural and rural sociology sought to harness social media to identify where food-security interventions are most needed before supply chains are disrupted. They analyzed Twitter posts in real-time to understand how people felt about their food situation and to provide insights into user behavior, emotional state, and sentiment during the COVID-19 pandemic. The findings could 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.
- Another team of researchers captured stances on the Black Lives Matter (BLM) movement through Twitter data. They found that Black people had a higher body mass index and prevalence of obesity in areas that showed higher negative stances on BLM. Stances against BLM were positively associated with implicit racism against Black people. The team concluded that negative societal sentiments around race-related issues may be detrimental to the health outcomes of minority populations.

Critical Issue: Developing Biologically Based Materials & Products

Below we highlight some noteworthy research from this critical issue this past year, *in addition to the key results featured in this report.*

- Pulsed light is an emerging technology that can serve as an alternative to current antimicrobial interventions in the food industry. A Penn State team sought to define the spectrum and energy characteristics of pulsed light, and to establish the germicidal response of several microorganisms that frequently cause foodborne illness. They concluded that microbial sensitivity to pulsed light treatment differs among microbial species and is predominantly attributed to the ultraviolet portion of the spectrum.

Critical Issue: Fostering a Positive Future for Youth, Families, & Communities

Below we highlight some of the noteworthy research and extension efforts from this critical issue this past year, *in addition to the key results featured in this report.*

- Penn State Extension's 4-H Youth Development team has conducted the Equity Guided Dialogues designed to bring youth and adults together to deliberate, reflect, and act on social justice issues. This closely aligned with efforts to increase youth civic engagement and leadership and career readiness skills. The Health Rocks Program helped youth build life skills that lead to healthy living choices with emphasis on youth smoking and tobacco use prevention. All youth participants reported their residence as "urban," which represents significant progress in reaching urban youth. During the programming year, the program saw an increase in youth enrollment of 10.2% and an increase in volunteer enrollment of 7%.
- The Farm Safety Extension team collaborated with other universities on a leaders' manual for the *National Safe Tractor and Machinery Operation Program* (NSTMOP). Adult instructors use the manual in an online course in preparation for delivering the 24-hour training to youth, and then conduct an exam and skills test for participants. The U.S. Department of Labor requires this certification for youth less than 16 years old who want to work off their family's farm. Almost 20,000 14- and 15-year-old youth are successfully

trained annually through this program, enabling them to work safely in agriculture and lessening the tight farm labor market. The skills they gain through the program provide these youth with valuable knowledge they can use throughout their career in agriculture.

- The Farm Safety Extension team reviewed an Occupational Safety and Health Administration database and found 314 fatalities nationwide from occupational tree felling from 2010 to 2020 in the logging and landscape services industries. They concluded that loggers should continue efforts to adopt mechanized harvesting methods, and that landscape services tree fellers should receive training related to fall prevention.

Critical Issue: Promoting Environmental Resilience

Below we highlight some of the noteworthy research efforts from this critical issue this past year, *in addition to the key results featured in this report.*

- Growing the right crop in the right place within an impaired watershed can achieve significant water quality improvements to Chesapeake Bay. That's the conclusion of an innovative algorithm developed to spatially reallocate crop rotations within existing agricultural land of the watershed of a tributary to the bay. The simulation reallocated hay onto landscapes most vulnerable to erosion and nutrient loss, and row crops such as corn-soybean rotations onto less vulnerable areas. The revisioning offers a potential way forward for farmers and policymakers to meet nutrient reductions for a healthier bay.
- A study examining whether restoration of fire-dependent ecosystems reduces ticks and tick-borne disease prevalence in the eastern United States looked at the ecological role of fire and its effects on forest-dwelling ticks, shifts in regional-scale fire use over the past century, and the possibility that frequent fire may have helped moderate tick populations and pathogen transmission prior to the fire-suppression policy of the past century. The team explored how fire and ecological restoration can reduce ticks, the potential for incorporating the mechanisms into the broader strategy for managing ticks, and the challenges, limitations, and research needs of prescribed burning for tick reduction.
- Numerous forests in the eastern United States have been degraded due to past exploitative timber harvesting known as high grading. A study led by Penn State foresters focusing on high graded mixed-oak stands aimed to develop a model that can identify past high grading and to determine modifications that may improve forest management recommendations provided by the prominent decision support tool, SILVAH (short for Silviculture of Allegheny Hardwoods). The classification model developed is a tool that forestry professionals can use to help inform and prioritize forest management decisions at different spatial scales when previous management information is lacking and to bring awareness to the pervasiveness of high grading.

Critical Issue: Supporting Integrated Health Solutions

Below we highlight some of the noteworthy research and extension efforts from this critical issue this past year, *in addition to the key results featured in this report.*

- The use of antimicrobials is usually associated with an increase in antimicrobial resistance in the animal microbiome and in the immediate environment. The livestock health research and extension team developed and delivered programs and resources on antimicrobial stewardship targeted at head veterinarians because they are key players in encouraging prudent and judicious use of these products by livestock owners, managers, and employees. The team presented concrete, economically viable actions to improve antimicrobial stewardship on farms via webinars and conferences, and in one-on-one settings.
- Bolstered by College, USDA NIFA, and other funds, the Soils, Plants, and Consumers Network (SPCN) brings together innovative researchers with combined expertise in food science, sensory science, plant science, soil science, ethnobotany, metabolomics, and toxicology. The SPCN has ongoing collaborative research projects on food and medicinal plants, including cacao, cloves, tea, grapes, hops, American ginseng, and goldenseal. The goal of the SPCN is to apply a novel systems-based approach to study the relationship between plants and consumers to support agriculture and improve public health, and to train the next generation of scientists to lead this area of research.

Merit and Scientific Peer Review Processes

Updates

Both PSE and AES programs undergo comprehensive review using several merit review processes.

Internal university panels will be used to review AES projects. The Hatch, McIntire-Stennis, Animal Health, and State projects will be internally reviewed at initiation by at least two qualified faculty. In addition, external university panels are used for Multistate Research Project (MRP) activities. Both extension and academic faculty are encouraged to participate to meet the jointly agreed objectives. These projects are reviewed multiple times through the five-year duration.

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

Combined internal and external university panels are assigned to each of the programmatic issues. These panels are integrated, multidisciplinary State Extension Teams (SETs) made up of field-based extension educators and faculty with split appointments in both extension and research. Team members broadly represent all parts of the Commonwealth, and faculty members are chosen to represent relevant research and extension perspectives. Extension Program Leaders provide overall leadership to the SETs, and programs are reviewed by extension administrators. State administrators and academic unit leaders serve as liaisons to each team. Each SET developed a program plan, based on logic model components, that will guide extension programming and applied research efforts.

Stakeholder Input

Actions to seek stakeholder input that encouraged their participation with a brief explanation

College administration and faculty advisory groups will confer regularly with key stakeholder groups, state and federal partners, and relevant industry representatives across the breadth of interests in the College. Listening sessions, targeted invitations, surveys, focus group meetings, and engagement on social media will all seek input from traditional and nontraditional stakeholder groups and/or individuals. A primary avenue for stakeholder input is via the various forms of feedback obtained in connection with extension offerings, from volunteered comments and formally sought assessments of learning and effectiveness to retrospective evaluations that seek to measure outcomes such as costs averted or profit increased from implementing extension program suggestions. All of these forms of feedback will be taken together to help set the course for PSE and AES programs. The results of these assessments will be incorporated into our Extension Program SharePoint site.

Methods to identify individuals and groups and brief explanation

The Methods to Identify Individuals and Groups submitted for the FY2022-2026 Plan of Work remains accurate and up-to-date.

Methods for collecting stakeholder input and brief explanation

The Methods for Collecting Stakeholder Input submitted for the FY2022-2026 Plan of Work remains accurate and up-to-date.

A statement of how the input will be considered and brief explanation of what you learned from your stakeholders

The Statement on How Input will be Considered for the FY2022-2026 Plan of Work remains accurate and up-to-date.

Highlighted Results by Project or Program

Critical Issue

Advancing Agricultural and Food Systems

Penn State Extension Agronomy Programming	Project Director Chris Houser	Organization Penn State University Park	Accession Number 7001753
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Teaching sustainable agronomic practices to farmers and service providers

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

In Pennsylvania, 25% of land is farmed. According to the 2017 Ag Census, more than half of is planted to field crops, with corn, soybean, and forages. Agronomic practices in Pennsylvania are evolving to meet the demands of a consumer-driven marketplace. Diverse needs of consumers are demanding more training for producers in various production techniques that are more sustainable in social and environmental ways. It is the goal of Penn State Extension to find profitability in these changing demands.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Field and Forage Crops Team conducted more than 9 facilitated discussion groups including 4 soybean breakfasts, 2 organic study circles, 2 soil and water discussions and 1 hemp production Q&A. Facilitation sessions are more difficult to track and evaluate, however we saw significant impacts from these type of events. Soybean breakfast sessions helped direct research that led to the development of two new research projects and changes to existing programs. Organic study circles, a model envied by other agencies, led to the award of a new \$46,020 contract to expand the effort. The efforts to date have reported 50% (n=6) of farmers attending have changed management practices on their organic farm. Management practices that changed included reducing tillage, diversifying rotations, and trying different types of weed control. A facilitated group of public, farmers and agency professionals hosted by Penn State Extension in Northern Pennsylvania secured \$510,000 in funding to support local watershed collaboration projects in 2022.

Researchers and educators hosted agronomic research at two research farms and over 30 farms across the Commonwealth. Trials included product evaluation, slug monitoring, cutworm trapping, planting population study, insect pest and disease monitoring, herbicide trials, cover crop seeding methods, nematode monitoring, organic rotations, saved seed trials, manure injection, nitrogen modeling and grain and forage evaluation of more than 300 hybrids. Efforts from research projects resulted in two new publications: "IPM Program for Soybean in Pennsylvania: A Comprehensive Approach to Controlling Invertebrate Pests, Weeds, and Diseases" and "EPA-Approved Products for Crop Management of Hemp." Tar spot, a new disease in Pennsylvania has been confirmed in 16 counties and counting. 12 presentations to more than 380 participants and 10 publications disseminated the warning quickly of this new disease.

Educational guest presentations, workshops, webinars, and activities continue to be the most efficient method for disseminating agronomic research. The team conducted more than 300 presentations for 16,349 adults and 1,744 youth. The team created more than 500 publications, videos, news and radio spots and conducted numerous other phone calls and site visits resulted in an additional 862,535 indirect contacts.

(1) The team continues to gear up agronomic economics education following recent retirements. We utilized new methods of outreach including hosting and presenting on podcast episodes. The teams articles on profitability has led to the formation of new tools available in 2023.

(2) In 2022, we filled the vacant forage specialists position, allowing the team to increase programing in the coming 2023 year. In 2022, the team was able to reach a high number of industry professionals and farmers through partnerships. Two educators serve on forage farmer boards to multiply efforts at the university.

(3) The IPM sub-team members reach out to the public by organizing in-person and online events; answering phone calls and emails from farmers; visiting farms on request; and creating a variety of educational materials that include extension articles, guides, podcasts, learn-now videos, short videos, and peer-reviewed articles. From October 2021 through September 2022, our team published 115 extension articles in the "Field Crop News" newsletter with more than 10 000 subscribers. Most of these articles were posted on the Penn State Extension Field and Forage Crops Team Facebook page and on multiple counties' PSU-Extension Facebook pages. In addition, many of the articles were published in local newspapers, and by and other media outlets like AgFax, Morning Ag clips, and Farms.com., to cite a few. The IPM team organized the Private Applicator Short Course that was offered in 7 counties and had 43 participants. Our team also collaborated with the Horticulture team to offer the Private Applicator Short Course in Spanish to 14 farm workers. In terms of presentations, our team members gave 151 presentations at both in-person and online events and reached 9892 participants. Our team members provided Agronomic Pesticide Updates, events where farmers continue to learn about the safe use, storage, and handling of pesticides, agronomic and forage crops, and obtain credits to maintain their applicator license. The total number of Agronomic Pesticide Updates hosted by the Field and Forage Crops Team was 68 and reached 1947 participants. In addition, to host this type of event, the IPM sub-team members contributed by preparing presentations about pesticide safety and communicating with the public about pesticide risk.

(4) The annual Farming for Success field day attendance in 2022 was just over 150 with about equal thirds, farmers, private industry reps, and other agricultural professionals in attendance. The field day, held at the Penn State Southeast Research and Extension Center, Manheim, PA offers a wide range of production ag topics, demonstrations, and presentations.

(5) Certification courses provided 39 individuals with Pennsylvania Act 49 Commercial Manure Hauler and Broker Certification. Continuing education opportunities were provided at 16 events with 44 credit opportunities to haulers and brokers where 434 individuals earned 1,025 education credits. Pennsylvania hosted the Manure Expo attended by 1,200 people, earning 1,288 continuing education credits. In 2021 Agri-applicators incorporated manure on 11,468 acres and in the spring of 2022, they incorporated 4,918 acres.

(6) Cover crops are the most cost-effective strategy for reducing sediment loss to waterways. Based on a 6-month follow-up survey of participants in the "Making Cover Crops Pay" webinar series (n=145), of 30 farmer respondents, 20 adopted cover crops on 3,796 acres for the first time. Of 8 farmer respondents who attended the Managing Cover Crops for Nitrogen session, 3 reduced the use of their synthetic fertilizer by 25-49 lb/A.

(7) The team completed 6 video case study videos on organic farms (<https://extension.psu.edu/farmer-to-farmer-case-study>) and conducted 2 organic study circles with a total of 50 participants. A 2022 survey of farmers that participated in more than one study circle over the past 5 years found: 100% (n=12) would recommend these programs to other organic farmers. As a result of attending these programs, 50% (n=6) of farmers indicated that they changed management practices on their organic farm. In late 2022, the Penn State Organic team was awarded a \$46,020 grant as part of the master agreement with the PA Department of Agriculture to help further organic study circle programming.

(8) The hemp sub-team maintains an industrial hemp website (<https://extension.psu.edu/hemp>, 1,168 unique visits in the past 12 month) which is linked to and coordinated with the PA Department of Ag hemp regulatory program. The declining interest in hemp has reduced the total offerings as expected. However, partnerships with industry and government agencies has consolidated, leading to more efficient information sharing. Members of the Penn State Hemp Extension Team also serve the Commonwealth by participation in the PA Hemp Steering Committee, and support the PA Department of Agriculture hemp program by creating educational resources to distribute to permittees.

Briefly describe how your target audience benefited from your project's activities.

Field and Forage Crops Team conducted more than 300 guest presentations, workshops, webinars, and activities for 16,349 adults and 1,744 youth. A survey of participants was conducted at the completion of many of these events. 1,358 evaluations were collected representing 323,924 acres of farmland. 774 individuals indicated they expected a positive cash impact to their farm as a result of attending. The positive future cash savings was estimated by those attendees to total \$3,011,564 as a direct impact of the lessons taught.

The team created more than 500 publications, news and radio spots and conducted numerous other phone calls and site visits resulted in an additional 862,535 indirect contacts.

(1) A dozen podcast episodes have been released to help reach a new agronomy audience. Two new tools are in development.

(2) The forage webinar participants indicated based on survey response, (n=16) 50% would use an IPM approach. 56% would start to use alternative forages in their grazing/ hay systems. Before the program, participants rated their confidence on using skills on a scale of 1-4, with 4 being the highest, percentages of level 3 and 4 responses were recorded: (n=16) soil fertility strategies- 44%; IMP- 19%; animal health- 44%; alternative forages- 25%; and forages sampling 25%. After the program, confidence levels of 3 and 4 were recorded for the same categories: soil fertility strategies- 94%; IMP- 93%; animal health- 93%; alternative forages- 94%; and forages sampling 82%. All attendees that answered the question "will this program have a positive cash impact on your operation?" answered yes. With average farm size and average dollar impact considered, this would be an impact of \$16,255.08, for the 12 who answered then question. Before this program 57% of participants said they did not utilize their agronomist. After the program, 84% said that they would.

(3)) Our scouting of fields revealed the real risk to soybeans from insects and pathogens and illustrated that preventative pesticides are not necessary to grow soybean profitably.

By trapping for black cutworm moths, we shared with growers which parts of the state experienced a greater risk for damage from black cutworm caterpillars and when to scout. This awareness limits unnecessary insecticide use and should better target insecticides against black cutworm when they are used.

By tracking and reporting Tar Spot, supporting the wheat scab fusarium risk tool, and providing free soybean cyst nematode testing for farmers, our sub-team provides quick response to statewide threats to crop security through disease monitoring, reporting and education.

(4) More than 170 farmers attended Crops Days and Conferences representing approximately 130,000 acres. Their evaluation impacts are summarized in the team impacts above.

(5) 39 individuals were able to successfully become certified manure haulers or brokers. Over 1,500 manure haulers and nutrient management planners were able to maintain their licenses through our programs.

(6) Based on a 6-month follow-up survey of participants in the "Making Cover Crops Pay" webinar series (n=145), of 30 farmer respondents, 20 adopted cover crops on 3,796 acres for the first time. Of 8 farmer respondents who attended the Managing Cover Crops for Nitrogen session, 3 reduced the use of their synthetic fertilizer by 25-49 lb/A. Of the 6 of 12 farmer respondents said they saved money as a result of attending at least one of the webinar sessions, averaging \$6 per acre.

(7) Organic grain crop farmers benefited by attending organic study circle and organic twilight meeting programs which encourage farmer to farmer learning. A 2022 survey of farmers that participated in more than one organic study circle programs over the past 5 years found: 100% (n=12) would recommend these programs to other organic farmers. 75% (n=9) had attended 4 or more organic study circle programs. As a result

of attending these programs, 50% (n=6) of farmers indicated that they changed management practices on their organic farm. Management practices that changed included reducing tillage, diversifying rotations, and trying different types of weed control.

(8) Hemp subteam communications with industry and agencies led to the formation of working groups that pool resources to handle hemp related issues. Hemp farmers and processors benefit from a single landing page to all hemp production content.

Briefly describe how the broader public benefited from your project's activities.

- (1) Improving the economic viability of farms in Pennsylvania is vital to rural economic health.
- (2) Forage production education is widely consumed by the public as landowners, equine owners or with ruminant animals as pets. The subteam also provides landowner education on wildlife food plots.
- (3) Our team's activities contribute to food safety by promoting the rational use of pesticides, the integrated management of pests, diseases and weeds; and practices that reduce the use of pesticides. These practices also contribute to the protection of water resources.
- (4) The broader public benefits from grain crop producers are in the preserving of the farm profitability and thus the maintenance of a strong commodity trade. This increase in grain in PA results in less out of state movement of grains into the state and reduces grain costs for feed. Which in turn lessens costs for milk meat and eggs directly. Improving yields reduces farmland needed to produce the same amount of food. Innovations in food technology and growing non-GMO, organic or high oleic crops changes food nutrition and consumer choice.
- (5) Reducing fertilizer and manure runoff potential will result in cleaner waterways and water resources. More efficient placement and better fertility calculations reduce excess and promote good environmentally sound practices that benefit the public.
- (6) The 3,000 more acres of cover crop will directly and immediately begin to improve soil quality and reduce runoff to streams and loss to the environment.
- (7) The broader public benefited by learning about organic crop production through presentations made by the team.
- (8) Hemp production coordination between state agencies, universities and processors help to understand the market potential of this emerging crop and help public officials better understand production impacts to inform legislation.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

The pandemic severely hindered direct meeting opportunities. However our team pivoted and did numerous online and remote diagnostics using technology to meet the needs of the clientele. Grant writing capacity limit the ability of the team to conduct more on-farm research. Merging of positions and vacancies continue to prove challenging to continue our reach.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Growing the high-yielding varieties from Penn State's forage variety trials adds nearly \$1,000 per acre to earnings, helping to increase long-term farm sustainability

Penn State Extension runs yearly forage variety trials. The goal is to provide unbiased, comprehensive, accurate, and assessable forage variety testing results to industry and producers.

The forage variety trials include alfalfa, clovers, cool-season perennial grasses, warm-season annual grasses, and short-lived winter forages and cover crops grown at the Russell E. Larson Agricultural Research Center at Rock Springs in central PA and/or the Southeast Agricultural Research and Extension Center at Landisville in southeast PA. Funding comes from a fee charged to seed companies to enter a variety in trials.

How valuable can non-biased alfalfa trial evaluation be to farmers? In Pennsylvania over the past 4 years, the yield of the top seven varieties has averaged 3.7 tons more per acre than the yield of the bottom four varieties tested. (We averaged the top seven varieties and the bottom four because those groups of yields were not statistically different from each other.) To a producer making variety selections (conservatively assuming a hay value of \$241 per ton and assuming 88% dry matter content), this difference would amount to an increase of \$976 per acre per year from selecting a top-yielding variety using variety trial data.

About 310,000 acres of alfalfa hay were grown in PA in 2022. If growers plant 25% of those acres using the top seven varieties in the trial, the total added earnings could be over \$75 million per year. (We used 25% of the total acreage in that calculation because about 25% of alfalfa acres open for replanting each year; it is a perennial crop typically grown for four years.)

Using tested high-yielding varieties can make a real difference in long-term farm sustainability. Growers are also advised to consider stand score (also evaluated in the forage trials) and pest resistance (assessed to a limited extent in the forage trials) in selecting varieties.

The 2022 Penn State Forage Variety Trials Report is available at

<https://extension.psu.edu/forage-variety-trials-reports>

Penn State Extension Poultry Profitability and Sustainability Program	Project Director Amber Yutzy	Organization Penn State University Park	Accession Number 7001775
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Poultry Profitability and Sustainability Education

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Pennsylvania's poultry producers have several challenges in their pursuit of feeding the growing population. Some of these challenges include biosecurity, poultry health, avian influenza, poultry welfare, rural/urban interface, management, nutrition, changing regulations, and changing consumer demands.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

The Penn State Extension Poultry team seeks to provide unbiased, holistic, and personalized educational programs and consultation experiences for a wide variety of producers across the state. The Extension Poultry Team focuses its educational programming on meeting the needs of both commercial and small/backyard flocks.

The topics identified through needs assessments for programming include biosecurity, catastrophic event prevention, poultry disease identification, poultry handling/transportation, flock management, nutrient management, pest

management, workforce development, animal welfare and gamebird, hunting preserve success. The Poultry Extension team addressed these issues through various educational delivery methods. Programs offered included:

- Sales and Service Conference and Northeast Conference on Avian Diseases

- Poultry Management and Health Seminar Series
 - Advanced course on avian diseases for veterinarians.

 - Introductory course on avian diseases for service techs and poultry producers.

- Basic Poultry Diseases Series
 - Disease training delivered as a part of the Certified Poultry Technician training offered by the PDA.

- Workforce Development
 - “Train the trainer” programs

 - Animal Science Apprenticeship Program

- Bed Bug Task Force

- Poultry Flock Talk webinars

- Ready, Set, Hatch! Webinars

- Living on a Few Acres webinars

- Animal Systems Plain Sect Hotline recordings.

- Poultry Handling and Transportation training

- PA Game Breeders and Hunting Preserves Conference

- Vegetative Buffers for Poultry Farms Webinar

- Catastrophic Event Preparedness Training

- TNT Poultry Grower Meeting

- Newsletter and media articles

Briefly describe how your target audience benefited from your project's activities.

The Penn State Extension poultry team provides various educational programs to address these challenges. Team members build programs focusing on operational biosecurity, disease identification, poultry handling and transportation, farm auditing, poultry management, integrated pest management, and more.

These programs are offered in various formats to broaden our reach. The team has reached nearly every state in the US and several countries with its outreach efforts. These programs have been offered as follows:

- Factsheets
- Webinars
- Radio programs
- Podcasts
- Certification training
- Symposiums
- Workshops
- Conferences
- Online courses

Team members reached 3,462 contacts directly, and team member materials were made available to 408,546 contacts through the Extension website.

As a result of the team's effort:

- 81% of respondents indicated they would implement game bird pen-building techniques presented at the PA Game Breeders Conference
- 84% of respondents indicated they would implement biosecurity strategies to protect game birds from HPAI
- 96% of respondents indicated they would call the state or federal hotline if they suspected avian influenza in their flock
- 100% of respondents indicated they would create a biosecurity plan

- 100% of respondents indicated they would enhance their biosecurity during times of high risk

- 89% of backyard flock owner respondents indicated they would separate their poultry species from wild birds and waterfowl

- 95% of backyard flock owner respondents indicated they would wear dedicated footwear and clothing when working with their poultry

- 98% of backyard flock owner respondents indicated they would limit contact with wild birds

- 100% of backyard flock owner respondents indicated they would limit visitors to their farm during times of high risk

- 100% of backyard flock owner respondents knew who to call in a poultry health emergency

- 80% of respondents indicated they would implement water treatment to enhance poultry health and welfare

- 80% of respondents indicated they would control temperature and moisture with heaters and ventilation systems to enhance poultry welfare

- 86% of respondents indicated they would adjust their stocking density to optimize poultry welfare

- 100% of respondents indicated they would use tools and sensors to monitor the barn environment

- 86% of respondents will/would like to invest in remote video monitoring to enhance poultry welfare

- 93% of respondents indicated they would revise their welfare plan to improve auditing success

- 100% of youth responders were “satisfied” or “very satisfied” with the Youth Poultry 101 offering

The team spent most of 2022 aiding in Pennsylvania's highly pathogenic avian influenza (HPAI) response efforts. Team members served on an HPAI Task Force, acting as chairs of several subcommittees (depopulation, disposal, vaccination). Team members also served as subject matter experts and liaisons in the PDA/USDA Joint Incident Command. Other team members led the diagnostic efforts in the Animal Diagnostic Laboratory. Finally, team members aided in depopulation,

disposal, and decontamination efforts on HPAI-infected premises under the guidance of state and federal officials. The impact of these efforts is enormous as team members have dedicated their time to protect this +\$7 billion industry.

Because such a large amount of time was spent on the HPAI response in 2022, the efforts of each team member have been outlined below. All of these efforts contribute to the program's impact.

Team member 1

- Served as the laboratory liaison for ADL to PDA/USDA Joint Incident Command.

- Incident Command conference calls:
 - 30 minutes per day, 7 days a week in the fall

 - 1-2 hours, 3-4 days per week in the spring

- PADLS Sample distribution planning call
 - 15 minutes per day, 7 days a week in the fall

 - 15 minutes per day, 5 days per week for 6 weeks in the spring

- PDA/PennAg Industry conference calls
 - 2 hours per week in the spring

 - sporadic in the fall

- PADLS conference call
 - 1 hour per week in the spring

 - sporadic in the fall

- Dean's HPAI update conference call
 - 1 hour per week in the spring; twice so far this fall

- Answering phone calls and emails regarding HPAI
 - ~1-2 hours per day, 7 days per week

- Accessioning (data entry/review) to support ADL Receiving technicians
 - average ~3 hrs/week in the spring

- Handling HPAI positive cases at ADL (communicating results to IC, submitting to NVSL for confirmation, etc.)
 - approximately 3 hours per case

- 5 cases through ADL so far this fall

Team Member 2

- Been deployed 7 times to the field
 - Lancaster and Berks counties
 - Estimated 90 hours of active participation in depopulation activities
- Given 9 presentations on HPAI in different forums, including 3 presentations during the Ag Progress Days
 - Creating awareness of the virus and the high need to adhere to strict biosecurity protocols.
- Created 7 newsletters
 - Published on the PSU Extension website
- Created and co-created 5 videos teaching people how to sample live and dead birds to detect HPAI properly.
- Participated in 3 Certified Poultry Technician training
 - Guest lecturer
- Created content teaching people how to detect avian influenza in poultry
 - Magnet
 - Rack cards
 - 2 flyers
- Given 5 interviews about HPAI
- Helped PDA review several biosecurity plans of PA poultry farms
- Conducted 3 biosecurity audits to poultry farms from PA

Team Member 3

- Composting subject matter expert
 - 6 weeks in spring
 - 7 days/week
 - 12 hours/day M-S
 - Half day on Sunday
 - 10 weeks in the fall

- 6-7 days/week
 - 10-12 hours/day
- Depopulation subject matter expert
 - As needed in spring
 - Commercial premises
 - Backyard flocks in summer and fall

Team Member 4

- Managed the Avian Influenza landing page on the PSU Extension website
 - 22,905 views in 2022
- Outreach liaison for USDA/PDA Joint Incident Command
 - 1-2 hours, 3-7 days per week in the spring
- Biosecurity plan review for PDA for continuity of business in control zones
- 10 interviews for media coverage of HPAI
- Filmed and edited 5 HPAI Sampler videos
- Coordinated HPAI Sampler training for PDA
- Oversaw on-farm HPAI Sampler demonstrations for PDA
- Served on the HPAI Task Force
 - 1 hour per month
 - As-needed meetings during the 2022 outbreak
- Dean's HPAI update conference call
 - 1 hour per week in the spring; twice so far this fall
- Coauthored 4 HPAI Biosecurity alert newsletters
 - Published on the PSU Extension website
- HPAI table at Ag Progress Days
 - ~45,000 attendees

Briefly describe how the broader public benefited from your project's activities.

Poultry programming impacts the broader public in both environmental and economic impacts. Educational programs help improve society and the environment through improved nutrient management practices. This means less energy is used to harvest animal feeds, indicating less pollution to water sources from runoff.

Improved healthcare practices mean that animals are less likely to need treatment, and increased biosecurity practice reduces the likelihood of a disease outbreak that could potentially affect the food supply chain. Animal welfare is improved through animal handling and disease prevention through better health care practices. This translates to less stress on the animals. Due to the outbreak of HPAI in our state, public education about the PA poultry industry was vital. Many questions arose such as "Are eggs safe to eat?", and "Can I still eat chicken?" It is important that consumers understand our products are safe for consumption.

Economic impacts from the Pennsylvania Poultry industry are significant to the economy. Pennsylvania is the eighth-largest poultry-producing state. The combined production value from broilers, eggs, and turkeys in 2020 was \$1.93 billion. The combined total was 70% broiler production, 18% egg production, 11% turkey production, and less than 1% from the sale of other chickens.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Preparing for an avian influenza outbreak: A tool kit

Highly pathogenic avian influenza (HPAI) has the potential to be a catastrophic disease in poultry, especially in turkeys and mature chickens. Sometimes the death is so sudden that there are few (if any) early indications of the disease in most flocks. Mortalities close to 100% of the flock may occur with HPAI infections.

The Pennsylvania Department of Agriculture (PDA) estimates that a major outbreak of HPAI in Pennsylvania could have an economic impact of \$13 billion and potentially affect more than 50,000 jobs and \$3.2 billion in wages. Pennsylvania ranks fourth in the nation in egg production and produces 8.2 billion eggs, worth \$478 million annually. Pennsylvania also has significant meat chicken, turkey, gamebird, and vaccine egg production that would be affected.

Wild waterfowl are known to carry the virus over vast distances. Wild birds have migratory routes close to poultry farms or small/backyard flocks that may be important to spreading the virus.

As of March 2022, HPAI had been detected in all four North American migration flyways. On April 15, 2022, HPAI was confirmed in commercial poultry in Pennsylvania for the first time since the 1983-'84 outbreak.

Penn State poultry scientists and Extension educators are diligently working with USDA and PDA staff to mitigate the spread of the virus in Pennsylvania. All poultry owners, whether they have one bird or one million birds, should be on high alert.

Penn State faculty members and extension educators serve on a statewide avian flu task force chaired by Pennsylvania's agriculture secretary. The group has developed action plans and procedures related to biosecurity, depopulation and disposal of infected flocks, issues relevant to small or backyard flocks, and other concerns.

The team has developed websites, videos, publications, and programs about how to recognize HPAI, boost biosecurity on a farm, and defend flocks against this disease.

Penn State's Animal Diagnostic Laboratory routinely tests poultry samples for the presence of avian flu viruses and other disease pathogens. Rapid diagnosis by the lab can contain avian flu outbreaks and limit costs.

Funding was provided by USDA NIFA and the Center for Poultry and Livestock Excellence in the Pennsylvania Department of Agriculture.

Closing Out (end date 07/11/2023)

Determining the factors guiding microbiome transfer between soils	Project Director	Organization	Accession Number
	Terrence Bell	Penn State University Park	1016233

★ Annual Report - Determining the Factors Guiding Microbiome Transfer Between Soils

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

In this project, we aim to understand the controls on microbiome transfer between environments, with a particular focus on soils. This has implications for biogeography (i.e. natural microbial movement through ecosystems) and microbiome manipulation (e.g. augmentation of soil microbes with specific functions).

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

We showed that the introduction of microbial products to soil is highly dependent on soil type (Kaminsky and Bell. 2022. Applied Soil Ecology). However, such differences can be countered to some degree, at least in sterile soils, by conditioning within different soil environments (Yates et al. 2022. Functional Ecology). We also proofed new approaches for assessing how different soil types receive incoming microbes in the field (King et al. 2022. ISME Communications). Finally, we examined how plant and animal hosts drive microbiome recruitment in different environments and at different scales (Assis et al. 2022. Journal of Zoology; Fleishman et al. 2022. Environmental Microbiome; King et al. 2021. New Phytologist; Sutherland et al. 2022. Molecular Ecology)

Briefly describe how your target audience benefited from your project's activities.

We communicated our results to the scientific community through publications (listed below) as well as a number of presentations, including at Wilfrid Laurier University, the University of Toronto, the Canadian Society for Microbiologists meeting, the ISME18 meeting in Switzerland, the Changing Microbiomes Symposium in Boalsburg PA, the Woody Roots Symposium in State College PA, and at the International Phytobiomes Conference in Denver CO.

Briefly describe how the broader public benefited from your project's activities.

Laura Kaminsky (PhD Student, Bell lab) communicated our results to farmers at the Farming for Success Field Day, hosted by Penn State.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional

development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Peer-reviewed journal articles:

Assis BA, Bell TH, Engler HI, King WL. 2022. Shared and unique responses in the microbiome of allopatric lizards reared in a standardized environment. *Journal of Experimental Zoology Part A* <https://doi.org/10.1002/jez.2665>

Kaminsky LM, Bell TH. 2022. Novel primers for quantification of *Priestia megaterium* populations in soil using qPCR. *Applied Soil Ecology* <https://doi.org/10.1016/j.apsoil.2022.104628>

Yates C, Trexler RV, Bonet I, King WL, Hockett KL, Bell TH. 2022. Rapid niche shifts in bacteria following conditioning in novel soil environments. *Functional Ecology* <https://doi.org/10.1111/1365-2435.14180>

Sutherland J, Bell TH, Trexler RV, Carlson J, Lasky J. 2022. Host genomic influence on bacterial composition in the switchgrass rhizosphere. *Molecular Ecology* DOI: 10.1111/mec.16549

King WL, Kaminsky LM, Richards SC, Bradley BA, Kaye JP, Bell TH. 2022. Farm-scale differentiation of active microbial colonizers. *ISME Communications* <https://doi.org/10.1038/s43705-022-00120-9>

Fleishman S, Eissenstat D, Bell TH, Centinari M. 2022. Functionally-explicit sampling can answer key questions about the specificity of plant-microbe interactions. *Environmental Microbiome* <https://doi.org/10.1186/s40793-022-00445-x>

King W, Kaminsky LM, Gannett M, Thompson G, Kao-Kniffin J, Bell TH. 2021. Soil salinization accelerates microbiome stabilization in iterative selections for plant performance. *New Phytologist* <https://doi.org/10.1111/nph.17774>

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Learning how to support soil microbiomes for crop health and yield

Penn State agricultural researchers are exploring how to sustain soil quality 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 must frequently use chemical fumigation or other soil-sterilizing approaches to kill disease-causing microbes, often wiping out beneficial microbes essential to plants.

The research team 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 affected the microbial communities’ composition in the recipient soil.

In the recipient soils with salt and nitrogen added, the accumulation of biomass and bacterial diversity was significantly constrained relative to recipient soils with no additives. This means that higher soil salinity and higher soil nitrogen delayed the re-establishment of a diverse soil microbiome.

The results of this study help to untangle the many factors affecting the recolonization of microbial communities that benefit crop production. The team’s findings are laying the groundwork for the development of guidelines that will help farmers improve soil fertility, and by extension, crop health and yield.

The [study](#) appeared in the journal *Environmental Microbiology*.

Funding from USDA NIFA and the National Science Foundation supported this work.

Closing Out (end date 07/11/2023)

Plant immunity and genome engineering for crop improvement	Project Director	Organization	Accession Number
	Yinong Yang	Penn State University Park	1016432



Annual Report - Plant Immunity and Genome Engineering for Crop Improvement

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Plant diseases such as rice blast and citrus greening have major negative impacts on agricultural production and the food supply. My research project focuses on expanding our knowledge on plant-pathogen interactions and developing new technologies to improve crop resistance and disease management for sustainable agriculture and environment.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

We have been studying the molecular mechanism of plant disease resistance in order to find novel strategies for control crop diseases. We have improved CRISPR/Cas9-mediated genome editing tools and applied them for efficient editing of rice and tomato. Multiplex genome editing has been performed in a commercial rice cultivar to improve yield and disease resistance. In addition, we have adapted and improved CRISPR/Cas12a-based methods for supersensitive and specific detection of citrus greening and phytoplasmal pathogens.

Briefly describe how your target audience benefited from your project's activities.

I have trained graduate students, postdocs and technicians for their theoretical knowledge and practical skills in molecular plant pathology and genome editing. Through collaborative research, publications, meeting presentations and seminars, our research activities and results have benefited other plant pathologists, geneticists and breeders in academia, industry and government agencies.

Briefly describe how the broader public benefited from your project's activities.

By elucidating the mechanisms of plant disease resistance and improving genome editing technologies for precision crop breeding and disease diagnostics, our project activities are expected to facilitate disease management, reduce crop losses and enhance food security, which would benefit the broader public and the society. Our outreach activities related to CRISPR/Cas also helped school children and the general public to have a better understanding of new genome editing technology and gene-edited crops.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to

communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Peer-reviewed journal articles:

- Li, H., Zhang, Y., Wu, C., Bi, J., Chen, Y., Jiang, C., Cui, M., Chen, Y., Hou, X., Yuan, M., Xiong, L., Yang, Y. and Xie, K. 2022. Fine-tuning OsCPK18/OsCPK4 activity via genome editing of phosphorylation motif improves rice yield and immunity. *Plant Biotechnology Journal*. 20:2258-2271. doi: 10.1111/pbi.13905.
- Wheatley, M. S., Qin Wang, Q., Wei, W., Bottner-Parker, K., Zhao, Y., and Yang, Y. 2022. Cas12a-based diagnostics for potato purple top disease complex associated with infection by ‘*Candidatus* Phytoplasma trifolii’-related strains. *Plant Disease* 106: 2039-2045. doi: 10.1094/PDIS-09-21-2119-RE.
- Molla K. A., Shih, J., Wheatley, M. S., and Yang, Y. 2022. Predictable NHEJ insertion and assessment of HDR editing strategies in plants. *Frontiers in Genome Editing* 4: 825236. doi: 10.3389/fgeed.
- Chen, K., Ke, R., Du, M., Yi, Y., Chen, Y., Wang, X., Yao, L., Liu, H., Hou, X., Xiong, L., Yang, Y., and Xie, K. 2022. A FLASH pipeline for arrayed CRISPR library construction and the gene function discovery of rice receptor-like kinases. *Molecular Plant* 15:243-257. doi.org/10.1016/j.molp.2021.09.015

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

New test allows rapid diagnosis of devastating citrus disease

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%. The disease has also spread to Alabama, California, Georgia, Louisiana, South Carolina, and Texas. Citrus is one of the most economically important fruit crops worldwide, valued at roughly \$17 billion.

The best hope for 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.

Penn State and USDA plant pathologists 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.

Early detection technology for disease diagnosis and quarantine of infected crops and insect vectors can minimize crop loss and prevent transmission into disease-free citrus-growing regions. CRISPR technology could provide a detection sensitivity level 100–1,000 times greater than the current diagnostic tests commonly used. The assay used for this test was shown to be compatible with lateral flow technology used to detect presence or absence of a target chemical, holding promise for providing rapid and economical testing for HLB in the field.

The journal *Phytopathology* published this [research](#).

Funding came from USDA Agricultural Research Service, with additional support from USDA NIFA.

Closing Out (end date 07/11/2023)

Collaborative Potato Breeding and Variety Development Activities to Enhance Farm Sustainability in the Eastern US	Project Director	Organization	Accession Number
	Xinshun Qu	Penn State University Park	1013768

★ **Final Report - Collaborative Potato Breeding and Variety Development Activities to Enhance Farm Sustainability in the Eastern US**

Final Result

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Pennsylvania potato grower and industry stakeholders have consistently indicated that they need improved varieties for both fresh and processing markets. These markets require varieties with earliness, good chip quality from the field and out of early storage, and tolerance to biotic stresses such as diseases and abiotic stresses such as internal heat necrosis and hollow heart. The overall goal of this project is to develop attractive, high yielding, disease-resistant potato varieties for fresh, processing, and/or specialty-type potato markets.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

In 2022, we conducted field trials to evaluate about 180 potato varieties/breeding clones at Penn State Russell E. Larson Agricultural Research Center at Rock Springs in Centre County, about 40 varieties/breeding clones in Northampton Co., and about 40 potato varieties/breeding clones in Erie Co. These varieties/clones included white-skinned, red/purple-skinned, and russet-skinned cultivars and were collected from different breeding programs and private companies in the US, Canada and Europe. We had an early season field evaluation trial (85-90 days) of 38 varieties at Rock Springs. We had early season out of field chipping trial with 8 varieties at Rock Springs. We had a trial to evaluate 115 varieties/breeding clones for heat tolerance at Rock Springs. We cooperated with Pa co-op, and Sterman Masser, Inc. to evaluate 8 varieties at three locations for potential to replace Norwis that may be economically viable to produce in Pennsylvania. After harvest in September and October, all tubers from all field trials are being evaluated for yield, tuber size and shape, internal and external defects, skin color, texture, specific gravity, overall appearance, French fry and chip qualities. High quality potato varieties for processing, fresh market and specialty are being identified and recommended to potato growers and industry. These varieties help small-, medium- and large-scale potato growers supply high quality, highly nutritional products to customers, while maintaining economically and environmentally sustainable production practices.

In 2022, 42, 252 and 53 varieties and advanced breeding clones were evaluated for resistance to early blight, late blight and common scab at Rock Springs in Centre County, respectively. Resistant varieties to each disease were identified and recommended to potato growers and industry. These varieties have good yields and better pest resistances resulting in improved productivity and/or reduced chemical inputs.

Briefly describe how your target audience benefited from your project's activities.

The target audience includes potato growers and industry in Pennsylvania and potato breeders and researchers in the US. In 2022, we had potato variety demonstration trial of 30 varieties at Rock Springs in Centre County which was shown to visitors during Ag Progress Days. We had potato variety demonstration trial of 30 varieties in Lehigh County which was shown to growers during Potato Field Day. We also provided new potato variety and disease management information to Pennsylvania potato growers and industry via meeting presentations, personal contacts, printed research reports, etc. Pennsylvania potato growers and industry depend on our potato research program to improve the quality and quantity of their potato production while staying abreast of consumer trends. Our field potato variety and disease evaluation data were shared with potato breeders and researchers in the US for use in developing new potato varieties.

Briefly describe how the broader public benefited from your project's activities.

We have a solid track record in producing new potato varieties that have been commercially accepted. Many major US varieties including recently released varieties such as Lamoka and Waneta (dominant out-of-storage chipping varieties in the US) and Lehigh (popular yellow-fleshed variety in eastern US) are products of this coordinated eastern potato breeding and variety development effort. Consumers benefit from the production of these potato varieties that provide high nutrients.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Peer-reviewed journal articles:

Xue WY, Haynes KG, Clarke CR, Qu XS. 2022. Genetic Dissection of Early Blight Resistance in Tetraploid Potato. *Frontiers in Plant Science* 13:851538. doi: 10.3389/fpls.2022.851538.

Haynes KG, Qu XS, Bamberg J. 2022. Germplasm Release: True Potato Seed (TPS) from a Late Blight Resistant, Long-Day Adapted Diploid Potato Population that is Segregating for Early Blight Resistance. *American Journal of Potato Research* 99:321–325. doi: 10.1007/s12230-022-09882-3.

Xue WY, Haynes KG, Qu XS. 2021. Resistance to *Phytophthora infestans* Clonal Lineage US-23 in Potato Cultivars and Its Relationship with Early Blight Resistance and Tuber Yield. *Plant Disease* 105 (12):3956-3966. doi: 10.1094/PDIS-03-21-0594-RE.

Pereira G, Mollinari M, Qu XS, Thill C, Zeng ZB, Haynes K, Yencho GC. 2021. Quantitative trait locus mapping for common scab resistance in a tetraploid potato full-sib population. *Plant Disease* 105 (10):3048-3054. doi: [10.1094/PDIS-10-20-2270-RE](https://doi.org/10.1094/PDIS-10-20-2270-RE).

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Penn State potato research program identifies top-performing varieties

Pennsylvania has more potato chip manufacturers than any other state in the United States. The manufacturers rely on the state's potato industry, which produces about 83,000 tons of potatoes each year, primarily white potatoes. Potatoes are a valuable

agricultural asset in Pennsylvania that accounts for thousands of jobs and more than \$1 billion in economic impact.

The growers rely on Penn State's potato research program to help improve the quality and quantity of their crops while staying abreast of consumer trends. The team works closely with potato growers to identify commercial potato production and disease problems and conducts laboratory and field experiments designed to provide critical information to solve these problems. The researchers share their findings through Penn State Extension programs and a publicly available annual report.

The industry requires varieties that allow early harvest, good chip quality, and tolerance to biotic stresses, such as diseases, and abiotic stresses, such as heat. Breeding programs in the U.S. and Canada are producing new varieties and breeding lines with yield potential and qualities for chip processing, french fry, and table stock use. The varieties are worthy of evaluation under environmental conditions and cultural practices found in Pennsylvania.

Penn State's potato research program evaluates about 200 potato varieties/breeding clones in variety evaluation trials and 200–400 varieties and clones in disease management trials each year. The work takes place at the Russell E. Larson Agricultural Research Center at Rock Springs, Centre County, and at grower sites in different parts of the state. The growers stress the importance of these evaluations in helping breeders decide which lines to release as new varieties, which lines to focus on for potential release, and which varieties are disease-resistant.

The team has contributed to developing more than a dozen popular varieties, including the Lehigh, named for Pennsylvania's Lehigh Valley, which served as a variety testing field site. This variety offers consistently high yields across diverse growing regions.

The Penn State team collaborated with Cornell University to release two potato chip varieties, Lamoka and Waneta. They estimate the value of potato chip production from Lamoka and Waneta for 2020 at more than \$1 billion.

The team is currently helping to evaluate how another consumer favorite, the Russet potato, grows in Pennsylvania's climate. Russets tend to be larger than traditional white potatoes and are a top choice for baking, mashing, and french fries.

Without this work at Penn State, smaller farms would be disadvantaged, especially those that do not have the resources to conduct research.

The Pennsylvania Department of Agriculture, the Pennsylvania Potato Research Program, the Federal Specialty Crop Block Grant Program, and USDA NIFA provided grant funds for this research.

Closing Out (end date 07/11/2023)

Multi-state Coordinated Evaluation of Winegrape Cultivars and Clones	Project Director	Organization	Accession Number
	Michela Centinari	Penn State University Park	1014131



Final Report - Multi-state Coordinated Evaluation of Winegrape Cultivars and Clones

Final Result

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Evaluating genotype x environment interactions in young wine grape growing regions such as the Northeastern US is crucial to avoid planting a poorly adapted cultivar in the wrong place, which is a costly mistake. Even if a cultivar

produces adequate yields, poorly adapted cultivars may ripen inconsistently, and produce inferior wines. In 2022, we evaluated viticulture performance of clones and hybrids of 'Riesling' (*Vitis vinifera*) a promising variety for our regional wine and grape industry to aid growers in choosing what selections can produce consistent yield and good fruit quality with lower disease incidence.

The recent introduction of new, interspecific cold-hardy hybrid cultivars has allowed for the growth of the grape industry in the Northeastern US. Some of these cultivars, however, tend to have early bud break which makes them susceptible to spring frost damage. In the 2022 fiscal year, we evaluated field practices that can reduce the risk of spring frost damage, which is one of the major environmental challenges to grape production in the Eastern US causing crop yield and revenue losses for grape growers.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

During the 2022 fiscal year, we conducted a side-by-side, well-replicated field trial to compare the most popular clones and hybrids (6 total) of Riesling (*Vitis vinifera*). We measured vegetative growth, yield, and fruit composition parameters to assess which clones and/or hybrids are more suitable for producing acceptable level of yield with high fruit quality. We also assessed fruit rot levels at harvest; Riesling is very susceptible to late season bunch rots which can significantly reduce the amount of healthy fruit suitable for winemaking. Briefly, we found that all Riesling clones evaluated in this trial had similar level of rot incidence and that rot severity decreased in all vines when leaf removal was implemented, suggesting that management practices aimed to improve fruit zone microclimate and fungicide penetration, such as leaf removal, are more important than clone selection, at least in terms of rot susceptibility. However, our data indicated that clones and hybrid of Riesling significantly vary in their yield potential.

The second trial was conducted on a promising cold-hardy cultivar, Marquette, which is prone to spring frost damage. During the reporting period, our research efforts focused on evaluating and comparing the effectiveness of traditional (delay pruning or double pruning) and experimental (spray-on products) practices that can delay bud break and consequently decrease the risk of frost damage. We also assessed the potential side-effects of these practices on grape production and fruit quality parameters. We collected phenology data twice per week in the spring and yield and cluster number data at harvest. At harvest, we also collected a cluster sample (10 clusters) from each experimental unit. The samples are currently stored in the freezer and juice chemistry will be analyzed in the winter to test the effects of the delay budbreak treatments on fruit maturity. Finally, we recorded the time needed for implementing these management (frost avoidance) practices to have a better idea on labor needs so that they can be more effectively implemented by growers.

Briefly describe how your target audience benefited from your project's activities.

The data collected from these trials were presented to stakeholders, researchers, and extension personnel at extension meetings. These presentations provided critical information on the viticulture performance and fruit quality potential of established and emerging wine grape cultivars and clones. Overall, our research can assist growers in adopting cultivars for optimal production and quality in a range of vineyard settings. These projects also offered training and professional development to three undergraduate students.

Briefly describe how the broader public benefited from your project's activities.

Broadly, the continued development and evaluation of wine grape cultivars and clones is critical for maintaining growth within this emerging agricultural sector which benefit not only grape growers and wine producers, but the whole agrotourism sector.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

n/a

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Identifying wine consumers interested in purchasing wines produced with environmentally sustainable practices

Some of Pennsylvania's wine makers are increasingly using environmentally sustainable practices, and they want to target marketing of these wines to consumers who are most likely to be motivated to make purchases based on these production practices.

The wine industry is important in Pennsylvania's economy. The National Association of American Wineries reports that in 2022, Pennsylvania wineries paid \$500 million in total taxes and \$2.4 billion annually in wages. The industry supported 53,900 jobs, yielding \$7.09 billion in total impact.

A Penn State viticulturist, consumer researcher, and food scientists aimed to characterize several wine consumer population segments that were "likely" to sample (taste before purchasing) wine from vineyards using cover crops and identify those with a greater probability of being a viable target market based on survey responses. Cover cropping—planting a crop below and/or between the vines to reduce soil erosion and the need for weed control spraying—is a sustainable production practice that reduces herbicide applications.

A total of 956 wine consumers from the Mid-Atlantic and bordering US states were separated into segments based on demographic classifications from internet survey responses.

Out of the 12 created segments, six contained participants who were at least 1.02 times more likely to try the wine compared to the overall sample and were willing to pay \$18.99 for a 750-mL bottle of the wine, which included a \$1 surcharge to cover associated production costs. Of these, three segments had the greatest potential for which a marketing plan could be developed, with more than half in each segment willing to pay \$20.99 for the bottle of wine. This could motivate growers to consider implementing this sustainable strategy.

Although several segments of participants were likely to sample the sustainably produced wine, the classifications based on internet survey responses allowed the researchers to identify participants who would not pay \$18.99 for a 750-mL bottle of wine, even after learning about the use of cover crops and the \$1 bottle surcharge. By narrowing the number of potential likely segments to those with a greater potential of sampling the wine, more purposeful marketing strategies can be developed based on demographics, attitudes, and behaviors defined in the model.

The [article](#) describing this work was published in the *International Journal of Wine Business Research*.

In addition to USDA NIFA funding, this research was supported by the Pennsylvania Wine Marketing and Research Board.

Critical Issue

Building Community Resilience and Capacity

Penn State Extension, New & Beginning Farmer	Project Director	Organization	Accession Number
	James Ladlee	Penn State University Park	7001720



New & Beginning Farmer

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

We created and shared general educational programming including online articles, videos, Exploring the Small Farm Dream curriculum as a webinar series.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

The program serves potential, new, and farmers seeking to diversify a current operation. These groups are seeking science-based information and advice about production, and many require information about the business aspects of their choice. They need this information to ensure their business is successful in the first ten years.

Goal.

The goal of the Team is to provide this information in ways that require minimal disruption to the client's normal schedules.

Objective 1.

To provide this information to the audience, the *Agricultural Alternatives* publication and article series covers topics for this target audience. The series covers, marketing, horticultural crops, livestock enterprises, business and insurance, and value-added topics.

From October 1, 2021, until September 30, 2022, the series had over 518,000 unique page views of the online articles. There are seventy titles in English and twenty-one titles in Spanish. Of the 518,000 total unique page views, 104,000 were from the Spanish titles.

These articles cover marketing of the crop or enterprise, production topics, and interactive PDF budgets are linked to the online article. The information provided allows the reader to have an overview of the topic covered allowing them to decide whether they wish to pursue the subject in more depth. The For More Information section provides places for the reader to find more information regarding the subject.

The reader can cover the information contained within the article in less than an hour unless they complete the budget for their operation. Creating an enterprise budget will require more time as the need for more in-depth information will require extensive research. This research will also the user to make a more informed decision.

Objective 2.

We conducted a four-week webinar series titled Exploring the Small Farm Dream which is a curriculum from the New England Small Farm Institute. This program was delivered in Partnership with Cornell Cooperative Extension. Penn State had twenty-six registrants.

Briefly describe how your target audience benefited from your project's activities.

Q3 - 1. After taking Exploring the Small Farm Dream:

#	Answer	%	Count
1	Unsure	7.14%	1
2	Disagree	0.00%	0
3	Somewhat Disagree	0.00%	0
4	Somewhat Agree	28.57%	4
5	Agree	64.29%	9
	Total	100%	14

Question	Unsure	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Total
I intend to start farming.	7.14%	0.00%	0.00%	28.57%	64.29%	14
I understand the use and purpose of a business plan.	0.00%	0.00%	0.00%	14.29%	85.71%	14
I know how to conduct market research related to an agricultural enterprise.	0.00%	0.00%	0.00%	50.00%	50.00%	14
I am familiar with different ways to access financing for an agricultural business.	0.00%	0.00%	7.14%	28.57%	64.29%	14
I understand how to identify a specific target market for my products.	0.00%	0.00%	0.00%	64.29%	35.71%	14
I have a better understanding about insurance products for an agricultural business.	0.00%	0.00%	14.29%	42.86%	42.86%	14

I know how to use risk management tools like SWOT, the checklist and enterprise budgets.	7.14%	0.00%	7.14%	35.71%	50.00%	14
I have made valuable connections with industry personnel.	7.14%	0.00%	21.43%	64.29%	7.14%	14
I have made valuable connections with fellow agricultural entrepreneurs.	7.14%	14.29%	28.57%	35.71%	14.29%	14
I am more familiar with magazines, websites, courses, and conferences about agriculture.	7.14%	0.00%	0.00%	35.71%	57.14%	14
I will seek further assistance from Penn State Extension.	7.14%	0.00%	7.14%	21.43%	64.29%	14
I will take additional Penn State Extension courses.	7.14%	7.14%	7.14%	21.43%	57.14%	14
Other	25.00%	0.00%	0.00%	0.00%	75.00%	4

Briefly describe how the broader public benefited from your project's activities.

If the target audience and their businesses thrive, they purchase goods and services from many suppliers. These purchases create a multiplier effect by supporting those businesses.

In September 2021, the Team launched the Developing Successful Farmers podcasts. In the year the podcasts were available, there were 211 downloads of 14 episodes. This podcast series allows clients to access the information at their leisure and wherever they are.

Our monthly newsletter currently has over 3,900 subscribers.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

The Team planned to hold an in-person conference during the reporting period. Due to many internal delays and issues regarding the planning and securing speakers, we did not have adequate time to receive outside support and registrations.

Q6. Communication of Results

Along with commissioners, legislators, internal Extension and University personnel, and grant funders, add others you communicate results with specific to the program/initiative you are reporting.

Our results are reported through Extension articles sent to relevant publications and posted on our website and through press releases.

Q7. Plans to accomplish goals in the next program year

Could include # of programs to be conducted, professional development/training, and revisions to program materials and others specific to program.

Planning has already begun and a more conference friendly facility has been secured for the 2023 conference. Speakers have been contacted and we should have over five months to advertise the conference. A supporting grant has been applied for to support the conference lowering the cost to attendees.

The *Agricultural Alternatives* series will have six to eight publications revised within the reporting period. One new publication will also be released. An online course covering business planning will also be released.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

New and Beginning Farmer Program links entrepreneurs to experts, knowledge, and each other

Pennsylvania is losing farm acreage, in part due to the rapidly aging farm population. The average age for all farm producers in Pennsylvania was 54.8 years in 2017, and the smallest proportion (3%) of all producers was under 25 years old.

To help counter that trend, Penn State's New and Beginning Farmer Program provides expertise on the nuts and bolts of operating many kinds of farms, as well as business start-up and planning information, such as what it takes to start a farm business in Pennsylvania and how to do business planning and obtain financing.

Participants run the gamut—from people who want to farm but have no experience, to people who have inherited land but aren't sure what to do next, to people who are already farming and want to expand into another farm enterprise. The enterprises span the traditional, such as Christmas tree farms, livestock, and poultry, to newer interests, such as goat yoga and event facilities and bison production.

One program participant in northwest PA planted a small orchard and is finalizing plans to sell hard cider. Some of the most valuable information he gleaned from the program was which agencies regulate his business, and the recommendation to get a business loan from the USDA Farm Services Agency rather than a bank. Getting connected with the expertise at Penn State's Fruit Research and Extension Center in Biglerville was invaluable for learning about fruit tree pests and diseases. Through Extension, he has become a certified pesticide applicator, learned about succession planning for his operation, and learned about registering the trademark for his products. He hopes to have beverages for sale by Thanksgiving 2023. He frequently refers to the extension website and often refers others there.

The New and Beginning Farmer Program offers education in many different media, including:

- the *Agricultural Alternatives* publication series, which includes 71 publications in English and 21 in Spanish providing introductory information to various agribusiness ventures. During the one-year reporting period, the series had more than 518,000 unique page views of the online articles.
- the *Developing Successful Farmers* podcast, which has had more than 400 downloads

- twilight in-person meetings
 - webinar series
- This research was supported by USDA NIFA funding.

Penn State Extension: Leadership & Community Vitality Programs	Project Director	Organization	Accession Number
	James Ladlee	Penn State University Park	7001769



One Community Many Generations

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Many communities would like to engage citizens in all-age inclusive planning, but don't have the knowledge or staffing to develop assessments and strategies for action. "One Community-Many Generations" (OCMG) uses assessment tools and planning process, followed by community action plans that emphasize intergenerational practice, to build age-inclusive, livable places.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

OCMG is an intergenerational placemaking program. Not only is there a focus on identifying and addressing the needs and interests of many generations (which meet the standard of "multigenerational planning"), the emphasis is on facilitating deep dialogue – across generations. This dialog is aimed at discovering the extent to which common concerns, interests, and visions for community life can be leveraged to create joint opportunities for collaborative Intergenerational community planning and action. The basis of the OCMG is collaboration between individuals, organizations, and agencies. This includes the process itself as well as future projects. OCMG assisted six communities in understanding key concepts about inclusive communities and the value of intergenerational planning. It also provided a tool for community leaders to gather community feedback and identified a process that was taught to community project leaders and volunteers for the develop action plans.

Briefly describe how your target audience benefited from your project's activities.

Post webinar written survey results showed that: • 50% of the communities (N=6) administered the OCMG survey • 50% of the communities (N=6) intended to conduct a community action forum within three months • The information received is going to be instrumental in improving community relations, exploring partnerships, and broadening our scope for planning (written comment). • The experience and the data are invaluable in our efforts to meet the challenges and opportunities this unprecedented time has laid before us. It has helped the cohort who participated understand what multi-generational planning means and to infuse our collaborative network with meeting the needs of all generations. It helped us to see how planning with and for various age groups creates a more vibrant path into the future (written comment). Participant follow-up interviews were conducted to identify ways by which the materials and processes were used and the directly and ripple impacts that were created. This included a two-year follow-up for the original pilot program, as well as three-to-six-month follow-ups for the webinar series participants. Examples of direct and ripple actions from webinar participants included: • Wayne Tomorrow initiated a Community Safety Campaign in collaboration with the PA Department of

Transportation that focuses on pedestrians, bicyclists, and motorists all working together to keep everybody safe. • The Selinsgrove Regional Engagement Center: o Redefined their scope for an intergeneration center to include the highly sought-after affordable housing options and intergenerational program. o Reevaluated and reassessed their support base and identified potential gaps in areas that they needed to make more or new contacts. o Created focus groups based on the results from the survey data – this will allow for programmatic bridges to be built, collaboration of community sectors, and more community wide communication and intergenerational visioning • New intergenerational programming is scheduled in Westmoreland County via a synergistic program called Weaving Wisdom • Susquehanna Depot (past pilot program evaluated for long term impacts in 2022) impacts included: o Bringing together organizations and people who would otherwise have been identified as “independent and autonomous”, o Volunteer installation of two stone benches that serve as a gathering place o Establishment of a Design Committee to identify additional projects that will include and or create other intergenerational spaces. o "The community now functions much differently than before the program, with many of the otherwise independent organizations now working together and leveraging precious community assets for integration into jointly envisioned projects"

Briefly describe how the broader public benefited from your project's activities.

Through a program that includes public intergenerational input and engagement, community service providers are better able to identify and prioritize needs that are truly in demand for all that they serve. Through projects, improved processes, better informed decisions, and community inclusion, the public as a whole is the recipient of services and facilities that can be utilized to the greatest extent possible.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Penn State Extension jump-starts community leadership around environmental issues

What stops people from leading and implementing local projects? How can we encourage volunteers to take action to address climate change?

With a \$10,000 Science-to-Practice grant from Penn State Extension and the College of Agricultural Sciences Office for Research and Graduate Education, faculty and educators from Extension’s Leadership and Community Vitality Team and Master Gardeners set out to find answers.

They started with the assumption that people don’t lead projects because they don’t feel they have leadership skills, and they don’t know how to get money to support a project.

To test this theory, the team surveyed more than 1,000 Master Gardener and Master Watershed Steward volunteers on their volunteer habits. The survey revealed that volunteers did perceive weaknesses in educating others, grant-writing, finding project funds, and communicating with local government. These results drove the training topics for a pilot leadership program.

Twenty-six volunteers from four counties enrolled in the pilot. Extension’s Leadership and Community Vitality team members taught participants about leadership styles, team development, working with local leaders, and conflict management. The grant-writing class proved to be most important. Participants learned about measuring impact and preparing a proposal.

Participants then worked in county-based teams to write grant proposals for local projects addressing environmental issues. They outlined their projects, explained potential project impacts, and prepared budgets. After evaluating the proposals and projects and providing feedback, the extension educators awarded funds from the Science-to-Practice grant to each team.

The county-based teams partnered with local leaders to carry out their projects. Teams cleaned and rejuvenated an overgrown garden at a state park; created a rain garden at a new municipal riverfront park; conducted soil-health testing experiments and offered training and soil test kits to community members; and partnered with a community volunteer group to educate residents about native plants and distribute native plants to low-income homeowners.

Teaching others about environmental issues was central to the project. The purpose of Master Gardeners is to educate others about why the environment is so important and how they can help.

Fostering independence in these activities was another overarching goal of the project. The skills gained will empower participants to seek funds and initiate community projects on their own.

In a survey following the program, more than half of the participants said they are more likely to lead a community project in the future, and 86% said participation improved their leadership skills.

Efforts are underway to expand the program statewide. A grant from the Pennsylvania Department of Environmental Protection funded a youth pilot program in 2022.

These programs are open to anybody, not just Master Gardeners or Master Watershed Stewards. The team hopes to motivate people to volunteer and make a difference in their local communities.

**Food Economics, Behavior,
and Health**

Project Director	Organization	Accession Number
Edward Jaenicke	Penn State University Park	1019915



Annual Report - NIFA Progress Report for Hatch Grant 4709

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

This project directly addresses this challenge by investigating the economics of food choice and health from a variety of perspectives. More specifically, the project will investigate a wide range of contributing factors that include the following: consumers preferences for product attributes, income and time constraints, nutritional awareness and advertising, attributes of the food environment, and policy nudges and interventions. The project will feature multiple methods to investigate this broad topic, including the analysis of both rich household-level food purchase data and primary data resulting from carefully designed experiments and surveys. The broad goals of this project are to better understand consumers' food choices (poor food choices in particular) to better inform policy that may ultimately improve diet-related chronic illness.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

This project started in July 2019, and the study team's accomplishments for the current period can be framed within the context of the project's three main goals (and sub-goals):

Goal 1. Model food decisions about food and health, and investigate how "micro factors" (price, product attributes, etc.) affect choices using multiple types of data.

Goal 2. Investigate how "macro factors" (e.g., the food environment, new marketing technologies, health trends) affect consumers' food decisions.

Goal 3. Investigate the policy implications of both micro and macro factors' influence on consumers' choices and health.

During fiscal year 2022, the project resulted in the following advances in research and scholarship related to the three goals mentioned above:

Accomplishments related to Goal 1:

- Ellison et al. (2022) indicates that, on average, consumers were averse to adding extra shopping trips to their weekly grocery shopping routines and would need to be compensated to do so (mean: \$24/week for one extra trip). Consumers would need to see approximately a 12 percentage point reduction in waste to be indifferent to adding one shopping trip to their weekly routine. Spending more to waste less resulted in more welfare gains, on average, yet there is significant heterogeneity in grocery shopping preferences.
- Irani-Kermani et al. (2022) shows not only that brand loyalty is important for consumer demand in a highly differentiated market such as the beer market, but also that improved methods to estimate household-specific brand-loyalty parameters can improve demand estimation.
- Vitt et al. (2022) show that maternal exposure to stress during pregnancy is linked to significantly less healthy food preferences and diets of children, highlighting a biological impact to stress resulting in hormonal or neurologic programming in utero.
- Vecchi (2022) investigates the impact of group decision-making on farmers' choices about using socially responsible products in their production. When farmers share the added profit from using non-socially responsible products, this gives them a moral wiggle room leading to less socially responsible purchases. Joint decision-making instead does not affect decisions.
- Zhang et al. (2022) finds that house prices have a positive impact on food expenditure, but no impact on diet quality. It also finds that the total quantity of food purchased increases as budget constraints are relaxed suggesting that changes in quantity are the primary driver of the expenditure change.

Accomplishments related to Goal 2:

- Baylis et al. (2022) shows that when trade agreements generate a decrease in tariffs, there is an increase in the number of import notifications, holding trade volume constant. This effect is strongest for those products that are rejected at the border for less threatening health reasons. Although there is clear evidence that non-tariff barriers are responding to health risks, they also appear to be correlated with demand for protection.

- Fan et al. (2022) finds that during Vermont's one-month mandatory Genetically Engineering (GE) labeling period, sales of GE-labeled soup products decreased by 5.9%, sales of non-GMO labeled products increased by 2.5%, and sales of organic products increased by 1.7%. Sales trends, however, reversed for all three product categories after Act 120 was repealed. The sales of GE-labeled soup products actually increased by 6% after the law was repealed in the medium term, suggesting improved attitudes towards GE products over time.
- Chen and Liu (2022) find that private label milk from different retailers are close competitors and retailers have more bargaining power than manufacturers. Further, factors such as the manufacturer size, private label share, and their private label position can significantly affect retailers' bargaining power. Moreover, the counterfactual analysis shows that lowering private label prices and other private label strategies such as private label program expansion and retailer advertising could not only increase their profitability but also allow retailers to benefit from the bargaining with manufacturers.

Accomplishments related to Goal 3:

- Fan et al. (2021) finds that making donations easier and the standardization of date labels were the most supported food waste solutions. Results are similar for the perception of the effectiveness of each food waste solution. Nevertheless, the percentage of respondents that considered each food waste solution to be effective was almost always less than the share of respondents who supported the solution. Thus, it is important to be cautious about this divergence when assessing public opinion on potential solutions, which may be enacted as policies are designed to mitigate food waste.
- Rabinowitz, Liu and Chen (2022) finds that that state milk pricing regulations have a significant influence on cost pass-through in the fluid milk market and the minimum price laws lessen the asymmetry commonly observed in farm-retail price transmission.
- Vecchi et al. (2022) find that being reminded about COVID-19 and its impact on individuals and their local communities decreases the willingness to pay for local food products. The authors show that the effect is mediated by the higher anxiety people experienced during the pandemic, and suggest managing anxiety might be one of the most important things in a future health crisis to sustain the local food economy.

Briefly describe how your target audience benefited from your project's activities.

In addition to the accomplishments described above, during fiscal year 2022, the project generated a wide number of outputs that benefit our target audience.

Peer Reviewed Publications:

Baylis, K., L. Nogueira, L. Fan and K. Pace. 2022. "Something Fishy in Seafood Trade? The Relation between Tariff and Non-Tariff Barriers" *American Journal of Agricultural Economics*, 1-23.

Chen, Xuan and Yizao Liu (2022). Private Labels Strategy, Retail Profitability and Bargaining Power in the Fluid Milk Market. Forthcoming, *Journal of Agricultural and Food Industrial Organization*

Ellison, B., L. Fan and N. Wilson. 2022. "Is It More Convenient to Waste? Trade-offs Between Grocery Shopping and Waste Behaviors" *Agricultural Economics*, 1-15.

Fan L., A. Stevens and Thomas, E. 2022. "Consumer Purchasing Response to Mandatory Genetically Engineered Labeling" *Food Policy*, 110: 102296.

Fan, L., B. Ellison and N. Wilson. 2021. "What Food Waste Solutions do People Support?" *Journal of Cleaner Production*. 330(129907): 1-13.

Irani-Kermani, R., Jaenicke, E.C. & Mirshani, A. 2022. Accommodating heterogeneity in brand loyalty estimation: application to the U.S. beer retail market. Forthcoming, *J Marketing Analytics*. <https://doi.org/10.1057/s41270-022-00187-2>

Rabinowitz, Adam N., Yizao Liu and Xuan Chen (2022). "The Impact of Price Regulations on Farm-Retail Price Transmission: The Case of Fluid Milk", Accepted, *Applied Economic Perspective and Policy*.

Vecchi, M., E.C. Jaenicke, and C. Schmidt. 2022. "Local Food in Times of Crisis: the Impact of COVID-19 and Two Reinforcing Primes." Forthcoming, *Agribusiness*.

Vecchi, M., 2022. "Groups and socially responsible production: An experiment with farmers." *Journal of Economic Behavior & Organization*, 196, pp.372-392.

Vitt, N., Vecchi, M., James, J. and Belot, M., 2022. "Maternal stress during pregnancy and children's diet: Evidence from a population of low socioeconomic status." *Nutrition*, 93, p.111423.

Zhang, B., D.H. Wrenn, J. Joshi, and E.C. Jaenicke. 2022. "Housing Wealth, Food Spending, and Diet Quality: Evidence from Panel Data. Forthcoming, *Agricultural and Resource Economics Review*.

Zimmerer, K.S., C.S. Duvall, E.C. Jaenicke, L.M. Minaker, T. Reardon, K.C. Seto. 2021. "Urbanization and Agrobiodiversity: Leveraging a Key Sustainability Nexus." *One Earth*, 4(11), 1557-1568.

Presentations: Invited

Jaenicke, E.C., J. Reed, Y Liu, E. Wang, and E. Zeballos, "Investigating Rational Addiction To Foods At The Household Level" Montana State University, May 6, 2022

Jaenicke, E.C., J. Reed, Y Liu, E. Wang, and E. Zeballos, "Investigating Rational Addiction To Foods At The Household Level" Arizona State University, Morrison School of Agribusiness, March 23, 2022

Vecchi, M., 2022. "Groups and socially responsible production: An experiment with farmers." Department of Applied Economics and Statistics, University of Delaware, April 12, 2022

Vecchi, M., 2022. "Online Food Advertisements and the Role of Emotions in Adolescents' Food Choices." Department of Agricultural Economics, Texas A&M University, October 28, 2022

Presentations: Annual Conferences and Professional Meetings

An, Yonghong, David Davis, Rui Huang, Yizao Liu and Ruli Xiao, Government procurement in welfare programs: Evidence and implications from WIC infant formula contracts, Indiana University, 10/2022

Cleary, Rebecca, Yizao Liu & Andrea Carlson. Inequality in the Distribution of Nutrition. **AAEA** 08/2022

Cleary, Rebecca, Yizao Liu & Andrea Carlson. Inequality in the Distribution of Nutrition. Annual Conference of the American Society of Health Economics, 06/2022

Fan, L., E. Zou, J. Feng, and D. Wrenn. "The Impact of Air Pollution on Comfort Food Purchases" **AAEA** 08/2022

Liu, Yizao, Lu Huang, Pei Zhou, and Hualu Zheng, The Effect of Polarized News in Consumer Learning of Product Health Information: The Case of Plant Based Milk, **NAREA**, 06/2022

Liu, Y., L. Fan and Y. Zhang "Information Framing and the Impact of Nutrition Label Serving Size Change" **AAEA** 08/2022

Pan, Y., L. Fan and S. Goetz. "Economic Shocks, Food Insufficiency and Mental Health during the COVID-19 Pandemic" **AAEA** 08/2022

Reed, Josh, Chiu-Lin Huang, Yizao Liu, Edward C. Jaenicke, and Xiao Dong, USDA Economic Research Service Urban-Rural Differences in Consumer Demand for Local and Organic Milk in Pennsylvania, **NAREA**, 06/2022

Reed, J.J., E.C. Jaenicke, Y. Liu, E. Wang, and E. Zeballos, "Rational Addiction To Foods by Obesity Status" **AAEA** 08/2022.

Simandjuntak, D., E.C. Jaenicke, D.H. Wrenn. "Heterogeneity in Consumer Food Stockpiling and Retailer experiences During Hurricane Sandy" **AAEA** 08/2022.

Vecchi, M., L. Fan, K. Keller, S. Myruski, R.M. Nayga. W. Yang. "Understanding the Impact of Online Food Advertisements and Emotions on Adolescents' Food Choices" 183rd EAAE seminar - Experimental and Behavioural Economics Research in Agri-Food and the Environment, September 8, 2022

Vecchi, M., L. Fan, K. Keller, S. Myruski, R.M. Nayga. W. Yang. "Understanding the Impact of Online Food Advertisements and Emotions on Adolescents' Food Choices" **AAEA** 08/2022

Vecchi, M., Vitt, N., 2022. "Stress or failure? An experimental protocol to distinguish the environmental determinants of decision making." 2022 ESA, September 1, 2022

Zhao, Y. L. Fan, A. Valdes, N. Wilson and P. Wilde. "Nutrition Objectives and Constraints for Low-Income Americans" **NAREA** 06/2022

Zhou, Pei and Yizao Liu, The Effect of Cross-Category Learning on Product Innovation and Market Expansion of Plant-Based Food, **AAEA**, 08/2022

Zhou, Pei and Yizao Liu, The Effect of Cross-Category Learning on Product Innovation and Market Expansion of Plant-Based Food, **NAREA**, 08/2022

Briefly describe how the broader public benefited from your project's activities.

Our projects outputs are aimed at the academic peers. However, in most cases, the results and accomplishments described above are relayed to the broader via press releases and news reporting.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

During fiscal year 2022, the project team mentored and supervised six or more graduates who worked on this project.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Consumer support for food-waste solutions

When it comes to reducing food waste, consumers most favor solutions that involve making food donations easier and establishing standards for food date labels.

Those are some of the findings of a study, among the first to examine support and perceived effectiveness for popular food waste solutions, led by an agricultural economist at Penn State.

The average U.S. household wastes an estimated 32% of purchased food. This amounts to \$240 billion in economic losses per year. Food waste increases food insecurity by decreasing global and local availability of food, tightening the food market, elevating food prices, and using natural resources unsustainably to harm future food production. Food waste also causes the loss of water, land, and labor used to produce food and incurs costs associated with the disposal and treatment of discarded food.

Several pieces of recent federal legislation have provisions aimed at cutting food waste in half by 2030, focusing on waste at retail and household levels.

Food waste solutions vary in expected costs, benefits, and the likelihood of success, but it's important to analyze people's support for and perceived efficacy of these solutions to assess the political feasibility of each as a policy option.

To gauge consumers' support for the suggested food waste solutions, the research team conducted an online survey of about 1,500 panelists matching the U.S. population in sex, age, income, race, and education. To participate, respondents had to be responsible for at least 50% of grocery shopping in the household.

The survey proposed nine solutions to reduce food waste: changes in food packaging, changes in portion sizes, standardization of date-labeling terms, selling imperfect produce in retail stores, making food donations easier, feeding uneaten food to animals, implementing composting in communities, creating consumer education campaigns on food waste, and taxing food waste. The survey also asked participants about their own grocery shopping behaviors that mitigate food waste and generation.

The scientists found that making food donations easier and standardizing date labels were the two most popular food waste solutions, with more than 90% support and more than 80% agreement of effectiveness.

As for ways to make donations easier, one possibility may come from a recently adopted law in France that bans supermarkets from throwing away edible food and requires them to partner with an organization that can redistribute food. Another possibility: Italy now allows outdated but safe food to be given to hunger-relief organizations.

Clarifying dates on food labels can help reduce consumer confusion about the meaning of terms such as "best by," which refers to quality, and "use by," which relates to food safety.

The survey also revealed that "Use uneaten food to feed animals," "Changes in food packaging," and "Consumer education campaigns on food waste" had similar levels of support from respondents, each with almost 90% of the respondents saying that they definitely or might support the strategy.

In comparison, 75% of the respondents definitely or might support "Sell imperfect produce in retail stores." "Taxing food waste" had the least support.

The percentage of respondents who considered each food waste solution effective was almost always less than the share of respondents who supported the solution. The gap between effectiveness and support rate could arise from difficulties in changing consumer behavior. This research provides policymakers with information that can be used to develop food waste policies that consumers will support.

This [work](#) was published in the *Journal of Cleaner Production*.

USDA NIFA provided funding for this study.

[Social, Economic and Environmental Causes and Consequences of Demographic Change in Rural America](#)

Project Director	Organization	Accession Number
Leif Jensen	Penn State University Park	1013257

★ Final Report - Elements of report for USDA National Institute of Food and Ag and Multistate Research Project 04623 (Accession 1013257) Social, Economic and Environmental

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Rural populations are changing in both size and structure. Changes in population size and characteristics affect a wide range of social and economic outcomes, but these changes are not automatic, mechanistic and are mediated by institutions, local community preferences and historical and cultural legacies. This project examines the causal pathways that link population change to rural and urban inequality, prosperity, and well-being in the United States and beyond.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

The project pursued three objectives. These are to (1) document rural (nonmetropolitan) population change, examine the dynamics of these changes and investigate their social, economic, and environmental causes and consequences, (2) describe the interrelationships between contemporary rural population change and inequality, prosperity, and well-being of rural people, places and institutions, and (3) describe the interrelationships between environmental shocks and stressors and the well-being of rural people, places, and institutions.

Leif Jensen continued work contributing to Objectives 1 and 2. With Brian Thiede (lead author), Jensen published a paper on Hispanic child poverty across immigrant generations. Results reveal poverty rates among Hispanic children that are very high overall. Hispanic children who are first generation or are second generation with two foreign-born parents have exceptionally high poverty risks. Differences in educational attainment among parents account for the largest share of the difference across immigrant generations. Elsewhere, through the W4001-inspired and NIA-funded Interdisciplinary Network on Rural Population Health and Aging (INRPHA) Jensen led the effort to continue building and supporting a network of rural demographers and social scientists in developing new research on rural health and aging. This effort led to a special issue of the *Journal of Rural Social Sciences* on this topic. It also catalyzed new funded research on the impact of embeddedness in social networks for cognitive health in rural areas and on rural/urban disparities in allostatic load, biological risk

profiles, and mortality. Finally, a Diversity Supplement under his NIA award is examining rural/urban differences in allostatic load and its impact on human mortality.

Brian C. Thiede published research on the effects of climatic variability on migration and health (Objective 1) and on inequality dynamics in the rural United States (Objective 2). He published papers on the effects of temperature and precipitation shocks on reproductive health outcomes and human capital development around the world. He also co-authored papers that examine spatial disparities in ethno-racial diversity and residential segregation across the rural-urban continuum, and developed a study that decomposed the drivers of changing income inequality between 1980 and 2019. An ongoing USDA-funded project examines the effects of natural resource development on economic and health outcomes in rural communities.

Guangqing Chi's published work has contributed to the project objectives in several ways. First, his work has linked bride kidnapping to gendered labor migration in rural Kyrgyzstan. Second, using nontraditional social media data, his work has built a linkage from exposure to anti-Black Lives Matter movement to the health outcomes among the Black population. Third, his published work has contributed to methodological and data innovations in using cell phone data for estimating national park visitors and Twitter data for estimating mobility patterns. Finally, Chi has continued his ongoing NSF-funded work on the implications of climate change for the well-being of native rural people in the Alaskan arctic.

Heather Randell published research on the linkages between climatic conditions and migration, women's participation in agriculture (Objective 1), and household food security (Objective 3). Randell also published a commentary piece on the impacts of and solutions to dam-induced displacement (Objective 3). A newly awarded NIH grant will allow Randell to explore the impact of residential displacement from dams and other large scale development projects on the wellbeing of women and children.

Kathleen Sexsmith disseminated research on the health and safety conditions in farmworker housing on Pennsylvania Seasonal Farm Labor Camps (Objective 2). This work contributed to the audience and public impact of the project.

Paige Castellanos co-edited a book on the gendered impacts of the COVID-19 pandemic in global contexts including the United States and many other countries in the Global South (Objectives 2 & 3).

Danielle Rhubarb (Penn State, College of Health and Human Development and W4001 multistate project team member) published research on the uneven distribution of social infrastructure in the U.S. - raising awareness and increased knowledge about access to spaces that can help facilitate health, well-being, and upward social mobility (Objective 2). An example of new knowledge generated by this research is that while aging and disability services are not evenly distributed across rural-urban and within rural contexts, older adult vaccination rates are higher in rural counties with higher densities of these types of facilities compared to rural counties with lower densities of these facilities.

Briefly describe how your target audience benefited from your project's activities.

Key target audiences for project researchers include scientific and policy communities. Sexsmith's work on health and safety conditions in farmworker housing in Pennsylvania informed policy recommendation to the Pennsylvania Department of Agriculture and brought information to farm employers on trends in violations of housing standards and for improving the farmworker housing inspection process. Project researchers drew on their research to inform presentations to policy stakeholder groups through a number of symposia and briefings. These include presentations for the Rural Health Day of the National Institutes of Health; a project-cosponsored U.S. Congressional Briefing on "Small Towns/Big Trends: Demographic

Insights on Living, Working, and Thriving in Rural America”; and a sponsored Rural Policy Symposium on “Rural Population Matters.” These presentations emphasized to policymakers the need for NIH and other funders to incorporate a rural oversample into existing large federally-funded cohort studies and to fund new data collection that oversamples rural residents. Rhubart’s work, based on technical assistance to the Pennsylvania Office of the Attorneys General, was used to allocate funds across the Commonwealth. Castellanos served as a steering committee member and co-lead for a gender affinity group for the USAID Feed the Future Community of Practice for Cross-cutting Themes to address gender equity issues related to agriculture, food security, and environmental change.

Briefly describe how the broader public benefited from your project's activities.

Project investigators have been oriented toward reaching the broader public with their research. Chi has published three op-ed pieces on topics including migrants, abortion, and rural bridges, in Slate, Philadelphia Inquirer, and the Conversation. Randell’s research reached the general public through a piece in The Conversation that discussed policy implications including increased investments in climate-resilient agriculture as well as in alternate forms of renewable energy. The various rural populations studied under this project also stand to benefit from its work. These populations include the immigrant farm labor employed in Pennsylvania agriculture and studied by Sexsmith, Hispanic children and youth studied by Thiede and Jensen, indigenous populations in Alaska, and others.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

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

Counteracting food supply issues exacerbated by climate change is a global problem. In countries such as Nepal, where the economy depends heavily on agriculture, predictable monsoon seasons that bring rain in the summer months 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 can trigger flooding and landslides and threaten to worsen the high rates of poverty and food insecurity.

Leveraging National Science Foundation funding with USDA NIFA Hatch Multistate project funding, a team of scientists examined data from the 2016 Nepal Demographic and Health Survey, which was distributed to women in 11,000 households in 73 of Nepal’s 75 districts. That information was integrated with earthquake intensity data from the U.S. Geological Survey and monsoon rainfall data from the Climate-Weather Research and Forecasting Model.

The impacts of monsoon rainfall on food insecurity differed by earthquake exposure. Low rainfall was linked with greater food insecurity in non-impacted areas. More rainfall was positively linked with food insecurity in affected areas. This is likely due to rainfall that increased landslides in earthquake-affected regions, damaging roads, disrupting the distribution of food aid, and destroying agricultural land and assets.

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.

This [research](#) was published in the journal *World Development*.

Critical Issue

Developing Biologically Based Materials & Products

[Biomass Properties and Performance](#)

Project Director	Organization	Accession Number
Daniel Ciolkosz	Penn State University Park	1019212



Annual Report - CopPyrolysis Performance of Biomass

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

A study was carried out on the performance of co-pyrolysis of biomass when co-mingled with waste tire materials, for the production of bio-oil. This addresses the need to utilize waste materials as well as the need to improve process performance when using biomass as a feedstock for bio-oil production.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

We developed a techno-economic model that used experimental data as a basis for estimating the mass and energy balance of a commercial system, as well as the expected economic returns from different configurations of system.

Briefly describe how your target audience benefited from your project's activities.

Bioenergy project developers will be able to use this information as a guide to optimize their designs for pyrolysis facilities

Briefly describe how the broader public benefited from your project's activities.

The broader public benefits in the form of new economic opportunities to produce and utilize biomass-based energy and products, as well as the ecological benefit that is inherent to the use of many of these bio-based products in place of less-sustainable alternatives. The supervision of students who took part in these projects also provides a benefit to the broader public, in the form of expanded human capacity to lead the development of bio-based, sustainably-oriented energy, materials, and related products.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Techno-economic analysis of the impacts of feedstock ratio on commercial-scale co-pyrolysis plants of biomass and waste tire

Renewable energy consumption has risen globally in response to sustainability-focused policies and technology developments. Biofuels contributed about 93% of the total amount of renewable energy used in transportation fuel in 2018 worldwide. Global biofuel production was 154 billion liters in 2019 and is projected to increase by

25% from 2019 to 2024. Although co-pyrolysis is not a 100% renewable process, it could serve as a “bridge technology” as the world transitions to renewable fuels. It would be even more attractive if it uses petroleum-based waste as the co-feedstock.

The development of a “circular economy,” in which existing materials are reused and recycled for as long as possible, is anticipated to be a key factor that will economically incentivize biofuel production from biomass waste. Approximately 25% of global primary energy could potentially be supplied by biomass resources.

The global annual production of agricultural biomass has risen to 220 billion dry tons, most of which is burned in open fields, aggravating environmental issues. Rice production worldwide in 2018–‘19 produced about 1,155 million metric tons of rice straw (RS). Worldwide production of waste tires (WT) has increased manifold over recent decades. The co-pyrolysis of RS and WT could be a promising technique to transform these waste products into energy while also alleviating various environmental and energy problems.

Visiting scholars from Pakistan worked with Penn State’s Agricultural and Biological Engineering department to model, based on experimental data, six types of commercial-scale pyrolysis and co-pyrolysis plants for RS and WT. Each plant was assumed to have a capacity of 20 tons/hour. The team comprehensively studied the impact of a range of feedstock ratios on the techno-economic performance of the plants.

The capital investment of plants ranged between \$17.0 and \$19.9 million. Plant A (RS only) had the lowest capital investment and Plant E (20% RS and 80% WT) had the highest. The operating cost was lowest for Plant A and highest for Plant F (100% WT) due to the cost of WT.

Pyrolytic-oil and char are the main revenue streams from the plants. The quality of oil produced from co-pyrolysis is superior to that derived solely from biomass. The gases produced are combusted to generate the energy required for the [pyrolysis reactor](#) and preheating of feedstock.

Plant E (20% RS and 80% WT) was the most economical alternative with the highest gross margin, highest net present value, and lowest payback time of 7.06%, \$5.63 million, and 6.23 years, respectively.

Sensitivity analysis indicates that oil selling price and WT procurement cost are the most influential factors affecting economic returns.

The authors caution that changes in fuels procurement costs will influence this analysis and note that the market for pyrolytic oil and char is immature.

This [research](#) appeared in the *Journal of Analytical and Applied Pyrolysis*.

The Higher Education Commission of Pakistan and USDA NIFA provided funds to support this work.

[The Science and Engineering for a Biobased Industry and Economy](#)

Project Director
Ali Demirci

Organization
Penn State
University Park

Accession Number
1017582



Annual Report - The Science and Engineering for a Biobased Industry and Economy

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Increased use of economically-viable and sustainable processes will require deliberate development and refinement of novel technologies. Implementation of economically viable and sustainable processes is urgent due to three converging issues: (1) decrease in productive agricultural land due to urbanization pressures; (2) using unsustainable methods to clear land for agricultural production; and (3) increasing world population with a rising per capita energy use and consumption of animal protein. One billion hectares of land will be cleared by 2050, resulting in the release of 3 Gt/year of greenhouse gases (Tilman et al., 2011). Global population will reach 9 billion by 2050, resulting in rising food demand from 2005 to 2050 (Tilman et al., 2011; Hochman et al. 2014). The breadth of these intersecting problems is so vast that constructive solutions can only be developed and implemented through collaborations that cross traditional disciplinary boundaries. Replacing existing petroleum-based energy and products with those that are stemming from biomass and other agricultural products will require research and development (Dale et al. 2014). Additionally, in order to determine whether novel processes and ensuing technology are actually making advances in sustainability, quantitative sustainability metrics need to be developed. These metrics are urgently needed to guide science and/or engineering approaches to increase sustainability of agricultural production and processing. The Land Grant University system can partner with important policy-setting agencies including United States Departments of Agriculture (USDA), Energy (US DOE), Defense (US DOD), and the National Science Foundation (NSF) for doing the research that will allow us to meet our renewable energy production goals.

1. Develop deployable biomass feedstock and supply knowledge, processes and logistics systems that economically deliver timely and sufficient quantities of biomass with predictable specifications to meet efficient handling, storage and conversion process requirements.
2. Research and develop technically feasible, economically viable and environmentally sustainable technologies to convert biomass resources into chemicals, energy, and materials in a biorefinery methodology including developing co-products to enable greater commercialization potential.
3. Perform system analysis to support and inform development of sustainable multiple product streams (chemicals, energy, and materials) and use the insights from the systems analysis to guide research and policy decisions.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Following research activities have been performed by co-PIs of this project during this reporting period.

J. M. Catchmark

Toward Goal 2, refined specific polysaccharide-based barrier product compositions for several companies focusing on food handling products such as corrugated cardboard, plates, bowls, straws and paperboard containers. Specifically, a coating solution was developed with the needed viscosity and particle size properties to coat the paperboard used in corrugated cardboard. In addition, coating formulations capable of replacing Per- and Polyfluoroalkyl substances coated papers used in food packaging and other applications were also developed. Comparable starch-based formulations were also developed using starches as the anionic and cationic polysaccharides. Many substrates were coated supplied by the companies mentioned above. Furthermore, continued to explore volume manufacturing of the paper coating composition with a company partner under a license agreement. In another

area, we have optimized a fully compostable starch-based polysaccharide foam useful for many applications including wound care and tissue regeneration, insulation for packaging and possibly buildings and aquaculture.

S. C. Chmely

For Goal 2, we have demonstrated our 3D printed materials have enhanced mechanical properties using surfactant-coated TOCNFs. Nanomaterials that contain the surfactant coating provide much enhanced strength and toughness to 3D printed materials. In addition, we have continued to develop our understanding of using Kraft lignin in 3D printable composite materials and are elucidating methods to enhance mechanical properties by using lignin. Finally, we have continued to study extraction and upgrading of lignin from switchgrass biomass and have begun collaborating with researchers in the Department of Chemistry to develop new catalyst materials that will allow us to isolate lignin with enhanced properties, which we believe will economically enable biorefining technology to produce liquid fuels from biomass.

C. Costello

For Goal 3, since quantitative analysis to estimate materials flows of nitrogen, phosphorous, and carbon through agricultural and bioenergy systems, we have made our model to calculate N & P flows nationally available on GitHub. We are currently developing a Chesapeake Bay-specific dataset and modeling framework. Additional model development has begun to represent how cultivation of duckweed using manure can capture and recycle nitrogen on-farm, and potentially reduce nutrient loading to the Chesapeake Bay. Similarly, model development is underway to estimate how N, P & C flows change as prairie grasses and/or anaerobic digestion of grasses with and without manure. We also worked on simulation of future climate in agricultural systems, focused on hydrology. This work uses process model data, historical data and statistical analyses to estimate changes in precipitation, soil water moisture, and crop water use for maize and soybeans into the next 60 years to determine adaptation needs.

A. Demirci

For Goal 2, the project to produce hydrolytic enzymes production from distillers dried grains with solubles (DDGS) for cellulosic biomass hydrolysis for biofuels and other uses have been continued. In this phase the study, the effect of dilution factor, agitation, and aeration in 2 L bench-top bioreactors was evaluated with *A. niger* and dilute acid-treated DDGS slurries. Furthermore, the fermentation parameters have been optimized in 2 L benchtop bioreactors. In a different study, vitamin K production via microbial fermentation have been scaled-up to 30-L pilot-scale by determining the most efficient scale up strategies. With a collaboration with Utah State University, Development of bioactive solid supports for immobilized *L. casei* biofilms and *L. lactis* biofilms in bioreactors for the production of lactic acid and nisin, respectively.

S. Irmak

In support of Goal 2, we have been working on developing new supported metal catalysts for hydrothermal conversion of woody biomass to hydrogen with an economically feasible approach. We have been synthesizing various bacterial cellulose- and woody biomass-based hierarchical carbon materials as catalyst supports to enhance activity of the supported metal catalysts for hydrogen production. Our lab has been also working on developing degradable biofilm formulations that can be used in agriculture for different applications. We have recently started a new project for developing woody biomass-based bioplastics that withstand environmental condition at least one season and degrade into safe end products in a reasonable time.

J. Liu

To support of Goal 1, deployable herbaceous biomass harvesting logistics and in-field processing systems were developed to meet efficient handling requirements. Participated in a USDA funded project: Mid-Atlantic Sustainable Biomass Consortium. It is a regional network of universities, businesses and governmental organizations dedicated to delivering a sustainable and economically feasible biomass for value-added products system in the Mid-Atlantic region of the U.S. This project leverages and strategically utilizes available resources and geographical advantages in the Mid-Atlantic region to facilitate expansion of the bioeconomy. My research focus is on increasing field efficiencies of switchgrass harvesting and optimizing field harvesting systems. I have recruited two M.S. students on this project.

J. Michael

For goal 1, we continued to work on a project to understand how standing timber can be more efficiently quantified in a way that carbon markets will recognize and value the carbon stored in trees. Also, conducted a critical evaluation of sustainability metrics related to wood fiber consumption and corporate attempts at quantifying environmental impacts in the form of footprint-type measures.

T. L. Richard

In support of Goal 1, we continued research measuring and modeling feedstock production and harvesting strategies that spatially identify and efficiently manage economically marginal land for bioenergy crops and ecosystem services. In support of Goal 2, continued to investigate microbial conversion of biomass into methane and carboxylic acids through various modes of anaerobic mixed culture fermentation, with patent disclosures for alkaline pH fermentations with high conversion rates to volatile fatty acids and high methane concentrations. We also characterized the microbiomes and identified organisms that tolerate these cotreatment conditions. In support of Goal 3, we continued experimental and modeling efforts to understand and enhance system-level opportunities to find synergies between profitable on-farm biomass production, advanced conversion technologies, and innovative market products, publishing papers that document feed and energy value of winter rye and demonstrate a value cascade for duckweed. We continued to quantify the increased greenhouse gas mitigation benefits of harvesting forest and crop biomass through smart carbon management.

H. M. Salis

In Support of Goal 2, transcription is a central biological process that controls protein expression levels inside cells, including enzymes that catalyze reactions. We have developed a new biophysical model that predicts site-specific transcription initiation rates in bacteria, library-based cloning, and next-generation sequencing to construct and characterize over 14000 synthetic promoters. We then applied biophysics and machine learning to train a thermodynamic free energy model capable of accurately predicting how well the transcriptional machinery binds to any promoter sequence and its corresponding transcription initiation rate. The model was then used to design synthetic promoters with desired transcription rates and to identify causes-of-failure in existing genetic systems.

J. Vasco

For Goal 2, we have designed a lab-scale solid-state bioreactor to mitigate dilute methane emissions, envisioning a biobased system that can be commercialized as a product and that benefits economically from carbon markets. We have developed a preliminary process model for the bioreactor and have produced some hydrochar materials to be used as packing for the system. For Goal 3, we have developed a superstructure-based model for the assessment of emerging routes for lignin valorization with biological upgrading, which allow us to rapidly compare technologies in terms of economic performance. In another project, we also developed a preliminary techno-economic analysis of small-scale pelleting.

H. Yi

For Goal 1, we developed a test device and protocol to quantify the flow behavior of milled biomass. This study includes the development of a computational model of target biomass flow behavior in specific handling equipment such as hopper and auger. We also developed a test device and protocol to quantify the particle-particle friction and adhesion which are hypothesized to be the origin of varying bulk flow behavior of biomass. We successfully characterized the bulk and inter-particle mechanical properties of corn stover and Southern pine residue particles of different anatomical origins. For Goal 2, we are developing a research program on intensifying the lignin-first fractionation process using a continuous or flow-through packed bed charged with milled biomass. We aim to develop an engineered biomass fractionation reactor design that can be scaled up with minimal issues.

Briefly describe how your target audience benefited from your project's activities.

Various stakeholders are being engaged through ongoing extension education programming that includes public presentations, short courses, websites (e.g. <https://www.huck.psu.edu/institutes-and-centers/center-for-biorenewables>, <https://extension.psu.edu/>, <https://cchange.research.iastate.edu/grass2gas> and <https://masbio.wvu.edu/>) scientific journal articles and extension publications. The project results will benefit biomass producers, the bioprocessing/fermentation industry and the rural public in general as a result of production of value-added products and bioenergy from raw agricultural products or by-products.

Briefly describe how the broader public benefited from your project's activities.

There is also strong public interest in understanding the environmental impacts of the biomass production and processing technologies for development of biofuels and other bio-based products as well as comparisons to conventional petroleum-derived products. Synthetic Biology and Fermentation companies have utilized our predictive models and design algorithms to accelerate their organism engineering efforts, which benefits the broader public by creating a portfolio of new consumer products that are more effective while being petroleum-free and sustainable. Biodegradable plastics will offer an environmentally sustainable alternative to conventional petroleum-based agriculture plastics and provide significant benefits for farmers. High yielding hydrogen will be beneficial for many industrial uses including hydrogen fuel cells, which have emerged as promising devices for future global energy needs, and ammonia synthesis for production of fertilizer. Increasing use of disposable plastics in packaging and food handling products constitutes a real threat to human health in the form of microplastic pollution. Work in this period focused on developing and translating to industry new agriculturally based barrier materials to replace disposable plastic coatings used in packaging and food handling products. This will continue during the next reporting period. Incorporating lignin into industrially relevant soft materials benefits several stakeholders, including PA farmers and foresters who provide feedstocks for our resin materials, industry partners looking to enhance the renewable and sustainable aspects of their products, and scientists and engineers working in the fields of materials science, agricultural engineering, and chemistry. Procurement personnel at higher education institutions (HEI) will better understand how individual employees make decisions with respect to choosing recycled content paper-based products, and HEI administration can therefore encourage purchases of more environmentally friendly bio-based products.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Describe and explain any major changes or problems encountered in your approach.

N/A

Opportunities for training and professional development if provided.

Demirci, A. 2021. Workshop on “Ten Vital Techniques for Accelerating Fermentation Expertise”, Center of Excellence in Industrial Biotechnology (CoEIB), University Park, PA, 12 participants, Dec 6-9. This was a hands-on fermentation workshop took place in CSL Behring Fermentation Facility at Penn State.

Demirci, A. 2022. Workshop on “Four Critical Concepts for Learning Fermentation Principles”, Center of Excellence in Industrial Biotechnology (CoEIB), University Park, PA, 10 participants, Sept 8 - Oct 6. This was virtual fermentation workshop took place during four Thursday afternoons.

Dissemination of results to communities of interest.

The target audiences for this proposed research include the science and engineering research community; biomass processing companies ranging from small start-ups to large multi-national companies; policy analysts and decision makers; potential biomass producers; bio-industry, environmental/water resources/ecosystems managers, waste managers, and the general public. Stakeholders include state and national organizations, state and federal agencies, companies, and industry consultants.

What the project or program plans to accomplish during the next reporting period to achieve the goals.

Several program goals are planned for the next reporting period: We will continue to work on utilization of biomass and by-products of agricultural, food, bioprocessing industries for the productions of biofuels as well as other bio-based products. We will continue to work with companies to develop and translate compostable agriculturally derived polysaccharide barrier materials for sustainable ecologically compatible packaging and food handling products; To work with companies to replace toxic fluorocarbon (Per- and Polyfluoroalkyl Substances, PFAS) based coatings in paperboard, paper based food packaging and textiles with lower-cost environmentally benign alternatives; and to optimize a new biomedical wound care and tissue scaffold material based on starch and establish a complete manufacturing process so new wound care products can be introduced into the market for both military and civilian use.

We will be engineering organisms to express enzymes that break down PET bulk plastic and microparticle plastic for use inside wastewater treatment plants and ocean environments.

We will be advancing in the development of biomass-based biofiltration systems, developing materials to pack the reactor and enriching microbial communities to inoculate the system. We will also finalize the building and testing of the biofiltration reactor and the superstructure optimization of biological lignin valorization optimized for economic feasibility.

We will continue to create soy- and lignin-containing 3D printing resins. We will also finish up our work on incorporating cellulose nanomaterials in these resins and we will have a clear picture of how those materials affect the performance properties of printed objects. We will also continue our work with the University of Tennessee to develop 3D printed scaffolds for bone implants. We will continue to work on developing new catalysts for conversion of woody biomass to hydrogen and new bioplastics for reducing plastic wastes in agriculture.

We will investigate the feasibility of using renewable bio-products in sports gear and apparel. This will include consumer acceptance and in-use performance aspects.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Biological engineers develop predictive model to rationally engineer organisms

Penn State bioengineers have developed a predictive model to rationally engineer organisms with useful biotechnology applications, such as converting renewable biomass into high-value products (e.g., fuels, materials, therapeutics, flavors, and supplements). They carried out more than 14,000 experiments and applied both biophysics and machine learning to train and test the model. The predictive model now enables engineers to quantitatively understand gene regulation in natural genetic systems and design new genetic systems with precise transcriptional control.

Organisms “read” their DNA and produce RNA and proteins through multistep processes called transcription and translation. The portion of the DNA that controls the rate of transcription is called the promoter. When researchers change the promoter DNA sequence, the organism responds by producing lower or higher amounts of protein, which can be beneficial for many biotechnology applications. However, in the past, it was not possible to quantitatively predict how a change to the promoter DNA sequence would affect the organism’s protein production rate.

In [research](#) published in *Nature Communications*, a team of Penn State bioengineers, including senior graduate student Travis La Fleur, former student Dr. Ayaan Hossain, and professor Howard Salis, carried out the intense experimentation to acquire the data needed to train and test a predictive model of transcription rate. The team calls the model a “Promoter Calculator.” To create the Promoter Calculator, the team wrote down a list of the molecular interactions that occur between promoter DNA sequences and the RNA polymerase enzyme that is responsible for initiating transcription. Then, using the data set, they applied a machine learning algorithm to learn how the promoter DNA sequence controlled the strengths of these molecular interactions. They tested the model predictions across more than 22,000 promoter DNA sequences in several scenarios, including rationally designing completely new promoter DNA sequences with targeted transcription rates across a 1,500-fold scale.

Over the past year, hundreds of researchers from around the world have used the Promoter Calculator to predict or design more than 20,000 different promoter DNA sequences for diverse biotechnology applications, using an interactive web-based design platform developed by Professor Salis. Instead of carrying out trial-and-error experiments to see if a genetic change is beneficial, researchers use the Promoter Calculator to design promoter DNA sequences with desired transcription rates. They also use the Promoter Calculator to ensure that other regions in the genetic system are not accidentally transcribed into messenger RNA, which frequently occurs in natural systems. Overall, researchers have used the laboratory’s collection of predictive models and design algorithms to engineer more than 900,000 genetic systems to reprogram organism functions across a range of applications, including for bioenergy production; to produce therapeutics, antibiotics, and the precursors to common pharmaceuticals; to make biodegradable plastics, food additives, nutritional supplements, and proteins that taste like meat; to break down plastics; and to detect contaminants in water or the food supply, among other uses.

Funds for this work came from the Defense Advanced Research Projects Agency, the Department of Energy, and the National Science Foundation, as well as USDA NIFA.

Critical Issue

Fostering a Positive Future for Youth, Families, & Communities

**Penn State Extension Health
And Wellness Programs**

Project Director
Elise Gurgevich

Organization
Penn State
University Park

Accession Number
7001693



FY22 H&W Program Results

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Our Penn State Extension Health and Wellness programs address the need for many Pennsylvania residents seeking help in adopting healthy behaviors and improving their health status. The 2021 America's Health Ranking by the United Health Foundation ranks PA 37th in recommended nutrition and physical activity behaviors, 36th in multiple chronic conditions, and 40th in cardiovascular disease. According to the 2021 Pennsylvania County Health Rankings, almost 1 in 5 (18%) adults in Pennsylvania report being in fair or poor health. In late 2019, a new virus emerged, the novel coronavirus SARS-CoV-2. This virus was new to humans and quickly became a world pandemic. To curb the spread, countries worldwide went into lockdown, and the phrase "social distancing" became the new buzzword. Unfortunately, most individuals and families were unprepared to transition to remote work and the lack of available childcare. The public also needed accurate, up-to-date information on preventative actions to protect themselves from infection and their communities from spreading the virus.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Healthy Lifestyle

Health and Wellness Newsletter

The Health and Wellness e-newsletter is distributed through email to those who have requested to receive it. The newsletter focuses on information addressing nutrition, exercise, healthy living, and mental health through articles and videos and registration links for workshops, webinars, and in-person events we offer. The Health and Wellness team created business cards with a QR card and a website URL to distribute at events to promote the newsletter.

Let's Cook

Let's Cook with Penn State Extension classes focus on easy-to-prepare, healthy, and delicious recipes for cooks of all skill levels. The goal of the classes is to help participants navigate their kitchens confidently to create more nutritious meals. The team continued to offer monthly webinars, Let's Cook at Home. Webinars provided information and meal ideas on plant-based diets, building healthy charcuterie boards, the DASH (Dietary Approaches to Stop Hypertension) diet, weight management, and the Mediterranean eating plan. Work continued with revising current lesson plans and developing new topics like seafood and pregnancy.

LIFT

Lifelong Improvements through Fitness Together (LIFT) is an eight-week, in-person, group-based resistance training program for adults aged 40+ that includes basic nutrition information with an emphasis on increased fruit and vegetable intake. From fall 2021 through summer 2022, one-hour LIFT sessions were held twice a week throughout the state.

Walking Programs

Everybody Walk Across Pennsylvania – A team-based or individual virtual eight-week walking program. The program's goal is for each individual or team member to walk

or exercise 10 miles per week on average. Individuals at any level of physical ability were encouraged to participate. Registrants were sent weekly email newsletters with healthy recipes, motivational messages, and walking tips.

Walk By Faith – Work continues on revising the curriculum to align with the Dietary Guidelines for Americans 2020-2025 before launching the program to extension educators and community groups as a train-the-trainer program.

Weight Management

In collaboration with Dr. Barbara Rolls, Penn State University professor and researcher, and based on her book, *The Ultimate Volumetrics Diet*, a 6-week webinar series including lessons, Volumetrics recipes, videos, demonstrations, interviews with Dr. Rolls, handouts, and small group discussion were developed and delivered in October and November of 2021.

Successful Aging and Adulting

Adulting

Based on a needs assessment, the target demographic (young adults 18-25) would not be reached through traditional programming methods. Our focus has shifted to creating short video lessons to teach the core concepts important to this group (food and nutrition, household handiness, financial firsts, career development, and personal health and wellness). Our primary mode of dissemination will be the PSU Extension website and the Extension YouTube channel.

Healthy Aging/Alzheimer's

The Healthy Aging/Alzheimer's team has partnered with the Alzheimer's Association of Greater Pennsylvania and Greater Delaware Valley since 2018. Through webinars and face-to-face programs, the following four programs were presented: Healthy Living for Your Brain & Body, Ten Warning Signs of Alzheimer's, Understanding Alzheimer's and Dementia, and Dementia Conversations.

Disease Prevention

Cancer Prevention

The Cancer Prevention in Pennsylvania Initiative is a collaborative initiative between Penn State Extension and the Penn State Cancer Institute (PSCI), whose goal is to reduce the burden of cancer in PA by increasing knowledge and awareness of risk factors and behaviors. Working together, factsheets, Learn Now videos, and handouts were developed. Two internal Lunch & Learn webinars on sun safety and nutrition as cancer prevention were presented to Food, Families, and Health educators.

Disease Management

Dining with Diabetes

Dining with Diabetes is a program for adults with type 2 diabetes or prediabetes and their families. This program helps participants increase their knowledge of healthy food choices and diabetes management. During the program, trained Penn State Extension educators across Pennsylvania led discussions addressing various topics related to Diabetes self-management, including meal planning, carbohydrate counting, medications, monitoring, and goal setting. The program consists of four consecutive classes and a three-month follow-up. Classes were offered both in-person and online.

Heart Disease

The heart disease team delivered webinars on Exploring the DASH Diet to Lower Your Blood Pressure, Let's Cook at Home: The DASH Diet, and Let's Cook at Home: Mediterranean. The Journey to a Healthier Heart is a no-cost 12-week program where registrants receive a weekly email to incorporate practical ideas into their eating plan to improve their heart health. Anyone can enroll in the journey at any time throughout the year.

Special Initiatives/Grants

EXCITE

The Penn State Extension Collaborative on Immunization Teaching and Engagement

is a project aiming to address health disparities among Latinx communities in Pennsylvania. The EXCITE team partnered with Latino Connection (LC) to create and deliver the #ItsWorthAShot #MyShotMyStory bilingual educational campaign in partnership with the City of York Bureau of Health. The project consisted of an interactive digital and in-person live campaign showcasing real-life stories of Pennsylvania neighbors and friends on their journey for COVID-19 vaccines. It included digital displays, social media messaging, and over 30 in-person events hosted by trained LC ambassadors and four COVID-19 vaccine clinics to reduce COVID-19 vaccine hesitancy and promote vaccine confidence. In addition, a radio and TV ad campaign aired through a partnership with Camara 809 FM/TV, a Hispanic radio based in Lebanon county.

Growing Healthy Hearts

Food, Families & Health Extension educators and the Master Gardeners are working with Penn State College of Medicine to develop a gardening intervention project specifically targeted toward adults at risk for heart disease. This research project is a digital gardening intervention aiming to improve fruit and vegetable intake and increase physical activity in participants who start and manage a garden. The desired outcome is to lower the risk of heart disease in adults by connecting gardening activities with nutrition education and a social support system.

Spice Project

This project aims to teach consumers how to use herbs and spices to decrease sodium, added sugar, and saturated fat. Survey results from the 2021 webinar, Let's Cook at Home: Herbs and Spices were used to develop the content of five short videos highlighting how to incorporate herbs and spices in a healthy dietary pattern. A research study evaluating the five videos' effect on diet quality changes is currently underway, with results expected in the next six months.

Well Connected Communities

The Well Connected Communities initiative in Aliquippa, PA (Beaver County) is addressing the low food access area (as defined by USDA Economic Research Center) through the work of the Aliquippa Food Council (AFC). Extension's Health and Wellness educator provided the leadership in establishing the AFC, with its first formal meeting in August 2019, and the council continues to meet monthly. Relationships and trust building are the key to policies, systems, and environment changes to allow for the good (healthy) choice to be the easy choice. The following projects and activities occurred:

- The Produce Cart Mobile Market
- The Aliquippa Wellness Festival
- Healthy for Life Cooking Classes (with skill-building activities)
- Seed to Supper Garden Program and community garden support

Briefly describe how your target audience benefited from your project's activities.

Healthy Lifestyle

Health and Wellness Newsletter

The monthly newsletter provides up-to-date articles and educational opportunities to assist readers. Healthy and simple recipes, with food safety steps, are included to encourage food preparation of wholesome foods.

Let's Cook

Six Let's Cook at Home webinars were offered, resulting in 212 registrants, with 151 attending live and 66 viewing the recordings.

- 94% (48/51) increased knowledge of safe food handling practices
- 96 % (49/51) increased knowledge of healthy eating patterns components
- 80% (41/51) were highly likely to utilize the information gained during the recipe demonstration to make one or more recipes at home

Comments from a participant included:

“Good “real” time presentation. This format was perfect showing aspects of recipe prep.”

LIFT

From 10/1/21 to 9/30/22, 95 classes were offered, with 1,118 enrollees. Evaluation data were collected through pre-assessments, post-assessments, and program evaluations completed by participants. Results are pending.

Walking Programs

Everybody Walk Across Pennsylvania - In the eight-week fall 2021 and spring 2022 programs, 923 people participated. Teams walked approximately 113,043 miles which equals walking across the state of Pennsylvania 399 times.

Evaluation results from both programs include:

- 83% (194/234) are interested in improving their health
- 57% (132/230) strongly agreed the program helped them to increase their physical activity

Comments from participants included:

“This program was exactly what I needed to get active, especially the reporting aspect. I have continued since the program ended. Thank you!”

“I love this program...very nice challenge, and it was good to know there were like-minded people out there walking in spirit with me. Thanks Penn State!”

Weight Management

70 participants completed the post-program survey after participating in the 6-week webinar series, and the results indicated the following:

- 76% (40/53) were likely to eat more low-calorie density foods and less likely to eat high-calorie density foods
- 74% (38/52) increased their knowledge and felt they were more likely to use the nutrition facts label to determine the calorie density of a food
- 96% (64/67) of participants increased their confidence in using Volumetrics habits to maintain a healthy lifestyle in the future

Comments from participants included the following:

“These webinars were wonderful. I am so glad I was able to participate. I have learned many new things and look at food in a different way now.”

“The series provided helpful information for us to adjust our behaviors/ habits/ lifestyles in a productive, but not too painful or drastic, way to achieve long-term goals.”

Successful Aging and Adulting*Adulting*

Evaluations in development.

Healthy Aging/Alzheimer's

As a result of attending programs, participants planned to make various changes, which reduce risk factors for cognitive dementia, including Alzheimer's. These changes may reduce cost savings for Medicare and other insurances, hospitalizations, and medications, increase productive lives and reduce early mortality.

Healthy Living for Your Brain and Body Program

- 54% (45/83) improved their knowledge of healthy living

Dementia Conversations Program

- 59% (13/22) gained knowledge about the benefits of early planning to build a care team for a person with dementia

10 Warning Signs Program

- 80% (27/40) gained knowledge of warning signs and challenges

- 65% (26/40) stated being more confident at discussing the ability to find help
- 80% (117/145) expressed a high possibility of contacting Penn State Extension again for future training

Disease Prevention

Cancer Prevention

The Cancer Prevention team updated and published a fact sheet on limiting red and processed meat to reflect the latest dietary guidelines and produced and published a short video on sun safety. A display and presentation on sun safety at Ag Progress Days were received with significant interest from attendees. Penn State Health Department of Dermatology distributed handouts, hats, and sunscreen samples.

Disease Management

Dining with Diabetes

The Dining with Diabetes (DWD) program reached 209 participants. The live webinar series reached 109 participants. Five in-person DWD series reached 52 participants. The DWD online program reached 48 participants during the program year.

A pre-post-program questionnaire from the live webinar indicated the following:

- 62% (10/16) reported the class positively affected their health
- At baseline, 90% (14 of 16) of participants could explain the importance of blood pressure concerning their health. At follow-up, the percentage had risen to 100%.

Comments from participants included:

“I learned new ways of preparing food.”

“I now know the importance of reading labels, eating various fruits and veggies, and exercising regularly.”

“My A1C was 6.7 in October, and I started eating better since taking the course. At my 6-month check, my A1C went down to 6.3, and I lost 16 pounds.”?

Heart Disease

The Heart Disease team presented three different webinars. “Exploring the DASH Diet to Lower Your Blood Pressure” was offered once (423 registered/176 attended live/43 viewed the recording). This team supported the Let’s Cook team when they offered Let’s Cook at Home: the DASH Diet and Let’s Cook at Home: Mediterranean webinar; each was offered once (evaluation results under Let’s Cook report). The 12-week email newsletter “Journey to a Healthier Heart” was distributed to 384 people (no evaluation is associated with this program).

“Exploring the DASH Diet to Lower Your Blood Pressure” webinar, 48 participants completed a three-week follow-up evaluation.

Participants indicated they could (very or extremely) accurately explain to another person the following:

- 81% (39/48) foods to eat or to eat more of
- 83% (40/48) foods to eat less often
- 85% (41/48) the difference between refined and whole grains

Participants reported the following changes in limiting (limited a moderate amount, a lot, and a great deal) in their diets: 77% (36/47) saturated fat, 87% (41/47) sodium, and 74% (34/46) added sugars.

Special Initiatives/Grants

EXCITE

- 1,223 people were reached through in-person educational events
- 3,190 COVID-19 test kits were distributed
- 978 COVID-19 vaccine/booster appointments were scheduled
- 35 COVID-19 vaccine doses were administered

Social media campaigns and digital displays reached over 37,000 people and had 938 engagements (likes, shares, comments, etc.). Feedback received included: “We really like this initiative because it was developed to inspire others to get the vaccine. We found this to be valuable for our congregation and us.”

Growing Health Hearts

Activities are being planned for 2023.

Spice Project

Data will be available in 2023.

Well Connected Communities

Aliquippa Food Council?– 23 organizations from Aliquippa and Beaver County and three residents are represented on the food council and providing guidance to address the low food access issue in Aliquippa.

The Produce Cart?– Collaborating with Community Partnership from Butler County, the Health and Wellness Educator provided data for a grant to establish a mobile market, which will accept SNAP benefits, WIC, and Seniors Farmer's Market coupons. The mobile unit has been retrofitted and will be ready for service in the spring.

The Aliquippa Wellness Festival?was held in April 2022 with over 50 vendors.

Extension's county Health and Wellness team took the lead in organizing the event and reaching out to the vendors. The vendors found the event beneficial to connect to help their clients, and they were excited this event took place in Aliquippa.

Healthy for Life Cooking Classes?– Extension's Health and Wellness educator received a \$2500 grant to conduct skill-building/cooking classes at the high school. Sixteen residents attend the four-week workshop and receive approximately \$300 in cooking equipment for use at home.

Garden Support/Seed to Supper?– Master Gardener's conducted the Seed to Supper program with six residents to help them learn to grow their food.

Briefly describe how the broader public benefited from your project's activities.

Healthy Lifestyle*Health and Wellness Newsletter*

The team has amplified the promotion of the newsletter to reach a broader audience to promote health and wellness and our educational resources. Creating a business card with a QR code and short link, distributed at various in-person programs, health fairs, and other community events, provided a direct link to sign-up to receive the monthly newsletter.

Let's Cook

The Let's Cook at Home webinars benefit the public by providing information and guidance to prepare quick and healthy meals using simple kitchen techniques. The cooking classes help the individual participants and the larger community. According to Family Cook Production, every participant taking a cooking class influences an average of 10 individuals in their circles. Therefore, 1,510 people were influenced by the total live participants (151) in the Let's Cook at Home webinars. Furthermore, Let's Cook with Penn State Extension was developed as a gateway class to introduce attendees to other health and wellness topics in which they may be interested. For example, webinar topics like weight management and the DASH diet segway to other programs offered by Penn State Extension.

LIFT

With the senior sector in our society increasing and their desire to stay independent, LIFT programming offers functional exercises vital for everyday activities and promotes an active lifestyle.

Walking Programs

The Everybody Walk Across Pennsylvania program has helped the public by demonstrating that program members increase their physical activity level when they are accountable for logging their miles and reporting these each week. Through a weekly newsletter, Penn State Extension's programs and resources were highlighted to raise awareness of other health topics, including healthy eating, disease prevention, vector-borne diseases, and mental health. An essential collaboration with the Penn State Cancer Institute provides information on cancer prevention.

Weight Management - Because of the increasing prevalence of obesity, the Volumetrics program was developed to provide research-based weight management information and strategies for the public.

Successful Aging and Adulting

Adulting

The adulting team has not completed any projects to reach the broader public this past year. Fast-frame videos planned for social media platforms will assist in reaching a previously underserved demographic.

Healthy Aging/Alzheimer's

A public health approach to healthy living initiatives is necessary to lessen the burden and enhance the quality of life for those with cognitive impairment and their caregivers and families. Partnering with the Alzheimer's Association provides Penn State Extension educators with resources to reach clients with important and practical information as they traverse this devastating disease. In addition, collaborating with local organizations provides us with an opportunity to reach a larger audience.

Disease Prevention

Cancer Prevention

The team's work contributes to increasing the information available to the public to support cancer prevention. Their presence at Ag Progress Days helped raise awareness of skin cancer and prevention for those in attendance, particularly for rural and farm families who spend considerable time outdoors and are exposed to the sun.

Disease Management

Dining with Diabetes

Dining with Diabetes is a program supporting those with Diabetes and those caring for others with Diabetes with practical information to help control blood sugar and minimize disease complications. Recipes demonstrated and distributed provide meal and snack options that are lower in fat, sodium, and added sugar and higher in fiber content. Recipes focusing on fruits and vegetables were highlighted in the monthly health and wellness newsletter to raise interest in healthy options and public awareness of the program.

Heart Disease

Heart disease is the leading cause of death for men, women, and people of most racial and ethnic groups in the United States. No-cost fact sheets, short videos, and a journey-style email series developed by the team on the DASH eating plan, heart-healthy diets, and heart-healthy Lifestyle are readily available on the Penn State Extension website. In addition, several webinars provided attendees with information and practical suggestions to support their desires to prevent or reduce high blood pressure.

Special Initiatives/Grants

EXCITE

While our target audience was Latinx, 41% of evaluation survey respondents did not identify as Hispanic or Latino, and 95% of all respondents chose to take the survey in English. This reflects the messages and educational content reached beyond our priority population and benefited the broader public in our communities.

Growing Healthy Hearts

N/A

Spice Project

The five short videos produced and highlighted using herbs and spices in recipes to create a healthy meal are being analyzed through a research study. The videos are expected to be placed on the Extension website in 2023 for viewing by a broader audience.

Well Connected Communities

Organizations and residents of Aliquippa are providing input and making decisions on how to address health and wellness issues through policies, systems, and environmental changes. While this work is slow, the outcomes are resident-driven,

with the goal of the community accepting the opportunities presented to address low food access and health and wellness issues. Penn State Extension's continued presence has allowed us to become a trusted partner and be part of the conversation to bring our resources into the community.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Healthy Lifestyle

Health and Wellness Newsletter

There has been a downward shift in the number of authors writing articles from the health and wellness team. This leads to either highlighting previous articles or only promoting one or two articles per newsletter. Due to this issue, the health and wellness newsletter team has been creating evergreen articles rather than focusing on timely articles throughout the year. With the transition back to in-person, there are fewer webinars to promote as compared to the number available during the pandemic. Many health and wellness materials are currently being updated, which will provide additional resources to promote in the newsletter. Tracking opt-in activity, which has begun, will provide information on the effectiveness of our continued newsletter promotion.

Let's Cook

The Let's Cook at Home webinars started as a cook-along format. The team quickly realized participants were not cooking along; instead, they were watching. Those who were cooking along became discouraged because they could not keep up with the presenters. Based on this feedback, the team decided to offer the webinars in a watch-only format.

LIFT

There is an opportunity to pilot LIFTed, a virtual delivery curriculum through Virginia Tech, to expand our reach. Instructor training will be offered biannually to increase the number of trained instructors.

Successful Aging and Adulting

Adulting

The major obstacle to our programming is reaching our target audience via media sources in which they are currently engaging. We will need university support to utilize these new mediums. Because this will not be the traditional workshop or webinar format, we will also require new methods of evaluating our impact. We are looking to partner with external organizations that support our target demographic, promote our programs, and work collaboratively to create education products that fill in identified gaps.

Disease Management

Dining With Diabetes

Due to the pandemic, the program series continued to be delivered primarily through live, virtual webinars to this vulnerable population. The team is revising the curriculum to include current blood pressure and diabetes management recommendations, providing an updated look to increase the appeal of the materials, and revising the program cookbook to include a wider variety of culturally diverse recipes. Educator training will be conducted to provide the necessary information to deliver the curriculum. The team plans to work with the marketing strategy specialist to expand our offering of resources and tools, including print and social media, for educators to promote the in-person program in their local communities.

Obtaining pre- and post-evaluations from live virtual programs continues to be a challenge. Many people do not click on QR codes or website links to complete the pre-survey at the beginning of the course. For those who complete this survey, many

forget their unique participant code, which prevents matching the two evaluations. The team plans to strategize with the evaluation specialist to address this issue by using polls during the live virtual programs. The current asynchronous online programs do not have an evaluation.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Making inroads on food access in Aliquippa, PA

The Penn State Extension Health and Wellness Team is working to address low food access in Aliquippa, PA, through the Well-Connected Communities program. They have been on the ground, forming trusted relationships and helping the community gauge its needs since 2019.

They helped establish the Aliquippa Food Council, including representatives of 23 organizations from Aliquippa and Beaver Counties, and private residents experiencing food insecurity and low food access.

The team is working on several fronts to make the healthy food choice the easy choice:

- In collaboration with the Community Partnership of Butler County, the team is starting a produce cart mobile market in spring 2023 so residents can buy fresh produce. The plan is for it to accept Supplemental Nutrition Assistance Program (SNAP) benefits, Women, Infants and Children (WIC), and Seniors Farmers' Market coupons. Extension began by surveying residents to determine what fresh produce, meats, poultry, and dairy products they wanted on the cart and when and where they wanted the cart. The team will support the training of the Community Partnership's nutrition education employee, who will be traveling with the produce cart and conducting demonstrations.
- The Aliquippa Wellness Festival was held in April 2022 with more than 50 vendors. Extension's county Health and Wellness Team took the lead in organizing the event and enlisting vendors. The event was well received, and vendors found it beneficial to connect with potential clients. Another festival is planned for September 2023.
- Extension's health and wellness educator offered Healthy for Life cooking classes via a small grant. Sixteen residents attended the four-week workshop, and each received approximately \$300 in cooking equipment for use at home, courtesy of local grant funds.
- The team is working with Master Gardeners to support the Seed to Supper Garden Program and community gardens, to help residents learn to grow their own food.

The extension team also has other efforts in the works, including:

- Explore the possibility of opening a community food co-op in Aliquippa.
- Collaborate with the high school to start a Youth Health Advisory Council to address food policies, systems, and environmental changes in the school and city.

- Work with a hydroponic freight farming business to explore starting a farmer's market in Aliquippa.
- Start to move the Aliquippa Food Council under the leadership of the Aliquippa Economic Development Corporation, with extension continuing to support all efforts.

The team emphasizes that none of this would be possible without long-term, trusting relationships in which all parties deliver on their promises.

The Robert Wood Johnson Foundation supports this work through the National 4-H Council and the Extension Foundation, as do grants from USDA NIFA, the Pennsylvania Department of Agriculture, and numerous small grants.

Critical Issue

Promoting Environmental Resilience

Ecological and biological interactions between spotted lanternfly and host trees in the landscape	Project Director	Organization	Accession Number
	Kelli Hoover	Penn State University Park	1021211



Annual Report - Impacts of spotted lanternfly on tree ecophysiology

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

There have been no studies on the impacts of any fulgorid species on hardwood tree ecophysiology and there are several common deciduous tree species that are hosts for spotted lanternfly (SLF). Knowledge of effects of SLF feeding on tree hosts will provide production nurseries, forest managers, and homeowners useful information for considering whether or not to treat SLF infested trees to prevent negative impacts.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

In a common garden, we documented impacts of SLF late-stage nymphs and adults on photosynthesis, nutrients, and growth of young silver and red maple, black walnut, and tree of heaven over two years in a common garden. In general, the effects of adults on trees were greater than nymphs, although there was variation depending on tree species and pest density. Late-stage nymphs on a single branch of red or silver maple at two densities (0, 15, or 30), or confined to whole trees or silver maple at four densities (0, 40, 80 or 120), had no significant effects on gas exchange. In contrast, 40 adults confined to a single branch of red or silver maple rapidly suppressed gas exchange and reduced soluble sugars in branch wood and nitrogen concentration in leaves. Fourth instars confined to whole silver maple trees reduced soluble sugars in leaves and branch wood, and reduced tree diameter growth by more than 50% during the next growing season. In contrast, fourth instars in whole tree enclosures had no effects on black walnut. SLF enclosed on tree of heaven at 80 adults per tree suppressed gas exchange after two weeks of feeding, but did not alter carbohydrates, nitrogen concentrations, or tree growth.

Briefly describe how your target audience benefited from your project's activities.

These results suggest that heavy feeding by SLF adults or fourth instars on young maple saplings may reduce tree growth, suggesting that nurseries and forest managers may want to treat young trees to avoid these negative effects. Mature trees are at less risk, although we have observed structural damage of maples at the union of main branches in response to heavy SLF feeding.

Briefly describe how the broader public benefited from your project's activities.

Homeowners should be aware that heavy feeding by SLF may reduce growth of maple saplings, but mature trees are probably not at risk unless they are heavily infested for more than a month and in more than one year in a row.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Zeroing in on egg hatch timing can help control spotted lanternflies

Invasive, non-native spotted lanternflies (SLF) are currently found in 51 counties in Pennsylvania, all of which are under a state-imposed quarantine. This insect poses a significant threat to Pennsylvania agriculture and natural ecosystems. If not contained, SLF could drain Pennsylvania's economy of at least \$324 million annually, according to a study carried out by Penn State economists.

A team led by Penn State researchers investigated the probability of egg hatch based on weather conditions and temperature. In controlled lab studies, the team evaluated sets of 30 individual egg masses at each of five constant temperatures. During field studies, they observed 112 marked egg masses throughout May and June for the emergence of first-instar nymphs.

The egg developmental rate increased as the constant temperature increased. The findings led to the development of an online tool to predict egg hatch (<https://tools.cei.psu.edu/slf/>) based on weather conditions and location.

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 Penn State Extension professionals can use it for surveillance efforts.

The [research](#) was presented in the journal *Environmental Entomology*.

USDA Animal and Plant Health Inspection Service and Pennsylvania Department of Agriculture funds were leveraged with USDA NIFA funding to support this project.

[Sustainable Solutions to Problems Affecting Bee Health](#)

Project Director	Organization	Accession Number
Christina Grozinger	Penn State University Park	1020527



Annual Report - Sustainable Solutions to Problems Affecting Bee Health

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Pollinators are essential for urban, agricultural, and natural landscapes. However, populations of both managed and wild pollinators are showing declines in the United States and across the world. These declines are caused by multiple interacting

factors, which can be difficult to identify, disentangle and address using strategies that are accessible by growers, beekeepers, land managers, urban planners and members of the public.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

- We developed a decision support tool and strategies to help ornamental plant breeders select for plants that will best be able to support diverse species of pollinators, and identified plants from current commercial stocks that are most attractive to pollinators.

- We demonstrated that creating successional forest and edge habitat through timber harvesting can improve flowering plant and bee species diversity.

- We evaluated user experiences and needs for our online decision support tool (Beescape) and identified strategies to improve the utility of this tool for evaluating habitat quality for bees by beekeepers, growers, conservationists and researchers.

- We demonstrated that climate and weather can have short and long-term impacts on the availability and quality of floral resources for bees and developed predictive models

- We initiated development of the “Penn State Pollen and Honey Diagnostics Lab” and the ‘Penn State Digital Pollen Library’, to help researchers and stakeholders identify the sources of bee-collected pollen and honey

- While the honey bee is the only bee tested for pesticide effects in the registration process currently by US-EPA, increasing evidence is being found that it is not a good surrogate for studying effects on many types of non-related wild bees, so we developed a standardized adult ingestion protocol for *Osmia* species that we hope will be used by EPA for the additional evaluation of a non-honey bee for future registrations.

- An evaluation of the pollinator communities in floral provision bee conservation plantings demonstrated that wild populations of several bee species was declining, the floral strips were benefiting wild pollinators known to pollinate apple.

- Pollinator communities of red maple, tree of heaven and wild black cherry that might be impacted by insecticides used for area-wide spraying of insecticides for the invasive spotted lanternfly.

- Spotted lanternfly control by homeowners and horticulturists using trunk injections or soil drenches were shown to persist into the bloom of maple and tree of heaven of the following season where they persisted at level high enough to affect adult solitary bees, but not the more tolerant honey bee.

Foliar applications have been shown to be safer to all bees as they do not persist until the bloom of the following year.

- A wild pollinator, *Osmia cornifrons*, that can also be managed in high numbers for pesticide testing, has been shown to be up to 10,000-fold more susceptible to some insecticides than the honey bee and that some fungicides alone which were thought to be safe to honey bees are toxic to some solitary bees.

- We have studied the role of beekeeping management on honey bee health and productivity. Our experimental work following the same honey bee colonies for 3 years and managed under three management systems has revealed two important findings: (1) chemical-free beekeeping management systems do not support healthy colonies and are not suitable for honey-producing operations; (2) managing colonies based on threshold level miticide applications and organic chemicals can support healthy and productive honey bee colonies. Colony survival for the organic and conventional systems was 20% on average, which is significantly lower than the national average of around 35% yearly.

- We have studied disease dynamics in managed and wild bees that pollinate cucurbit agroecosystems. Our studies have demonstrated that honey bee pathogens (viruses, bacteria, and eukaryotes) are commonly detected in wild bees but that the levels of infections of these honey bee pathogens in other bees are low.

- We experimentally compared several honey bee genetic stocks widely used by beekeepers in the mid-Atlantic region for colony health and productivity. Our results show clear differences between genetic stocks with locally bred lines (from Indiana and Pennsylvania) overperforming compared to stocks from reared in southern latitudes.

- We published a long-term monitoring study of the dynamics of bee communities in Pennsylvania for 6 years. Our study shows that bee communities shift across the year (little overlap in community composition every month) and that about 33% of the species showed declines over the 6 year period.

Briefly describe how your target audience benefited from your project's activities.

- We developed decision support tools that can be used by plant breeders, growers, beekeepers and conservationists to improve management of habitats to support bee communities in diverse locations.

- In conjunction with USApple, a group of fruit IPM specialists, a 14 page Best Management Practices Guide was developed for apple growers and bee keepers to protect both managed and wild bees from pesticides and is available online at USApple.

- Pesticide recommendations to increase insecticide and fungicide safety to wild pollinators have been implemented in Penn State Tree Fruit Production Guide which is a regional guide for the mid-Atlantic states.

- We established a bee monitoring program for the state of Pennsylvania based on participatory science. We have been working with 20 Master Gardeners across Pennsylvania to improve our knowledge of bee diversity in the state, and train project participants on topics related to bee monitoring and biodiversity.
- We have offered online and in-person training to beekeepers related to best practices for organic beekeeping management. We trained over 150 beekeepers in 2022.

Briefly describe how the broader public benefited from your project's activities.

- Our decision support tools are available to members of the public
- We have presented our research to beekeeper groups, garden clubs, civic organizations Master Gardener groups across Pennsylvania and the United States
- We developed lesson plans and interactive digital games highlighting pollinator biology, ecosystem services and management for K-12 teachers in collaboration with Penn State's Center for Science and the Schools
- Educational programming highlighting the importance of pollinators and pollinator habitat construction has been developed and offered to visitors through the Pollinator and Bird Garden at the Arboretum at Penn State
- An 86 pg IPPM guide with over 100 photos was co-developed in conjunction with the Xerces Society for commercial and backyard fruit growers and the general public demonstrating ways to control pests in an ecological manner through pesticide selection and timing of application that would conserve pest biological control and managed and wild pollinators.
- Two pollinator identification and natural history workshops have been given to train extension educators and Master Gardeners that interface directly with the general public.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

In total, our team has provided training and opportunities for 6 postdoctoral fellows, 20 graduate students, and 6 undergraduates in 2022

Our research has generated the following publications in the scientific, peer-reviewed literature:

- Turley, N., **D. Biddinger**, N. Joshi, and **M. Lopez-Urbe**. 2022. Six years of wild bee monitoring shows changes in biodiversity within and across years and declines in abundance. *Ecology and Evolution* 12(8). DOI:10.10002/ece3.9190.
- Heller, S., J. Fine, N. Phan, E. G. Rajotte, **D. J. Biddinger**, & N. K. Joshi. 2022. Toxicity of formulated systemic insecticides used in apple orchard pest management programs to the honey bee (*Apis mellifera* (L.)). *Environments* 9(7):90. DOI: 10.3390/environments9070090.
- Crone, M. K., **D. J. Biddinger**, and **C. M. Grozinger**. 2022. Wild bee nutritional ecology: Integrative strategies to assess foraging preferences and nutritional requirements. *Frontiers in Sustainable Food Systems* 14 April, 2022. <https://doi.org/10.3389/fsufs.2022.847003>
- McLaughlin, R., J. Keller, E. Wagner, **D. Biddinger**, **C. Grozinger**, & K. Hoover. 2022. Insect visitors of black cherry (*Prunus serotina*) (Rosales: Rosaceae) and factors affecting viable seed production. *Environmental Entomology*, vol, 51(2): 471-481. <https://academic.oup.com/ee/article-abstract/51/2/471/6501647>
- Allen-Perkins, A., A. Magrach, M. Dainese, L. A. Garibaldi, D. Kleijn, R. Rader, J. R. Reiley, R. Winfree, O. Lundin, C. M. McGrady, C. Brittain, **D. J. Biddinger** et al. 2022. CropPol: A dynamic, open and global database on crop pollination. *Ecology*, 103(3): DOI: 10.1002/ecy.3614.
- Belsky, J., **D. J. Biddinger**, N. Seiter, and N. K. Joshi. 2021. Various routes of formulated insecticide mixture whole-body acute contact toxicity to honey bees (*Apis mellifera*). *Environmental Challenges*, Dec. 2021. <https://doi.org/10.1016/j.envc.2021.100408>
- Elmqvist, J., **D. Biddinger**, N. Phan, T. Moural, F. Zhu, and K. Hoover. 2022. Neonicotinoid residues in flowers of red maple and tree of heaven following post-bloom insecticide application for control of the spotted lanternfly, *Lycorma delicatula* (Hemiptera: Fulgoridae). *J. Economic Entomology* (in press)
- Elmqvist, J., K. Hoover, and **D. Biddinger**. 2022. Insect floral visitors of red maple and tree of heaven at potential risk of neonicotinoid residue exposure from spotted lanternfly control. *J. Economic Entomology*. Submitted to *J. of Economic Entomology* October 2022.
- Phan, N.*, N. Joshi, E. G. Rajotte, K. Peter, and **D. J. Biddinger**. 2022. Systemic pesticides in the pollen stores of the Japanese orchard bee (*Osmia cornifrons*) affect its larval development and increase pupil mortality. Submitted to *PlosOne* October, 2022.
- Prestby, T.J., Robinson, A.C., McLaughlin, D., Dudas, P.M., and **C.M. Grozinger**. “Characterizing user needs for Beescape: A spatial decision support tool focused on pollinator health” *Journal of Environmental Management* 325: 116416 (2023). <https://doi.org/10.1016/j.jenvman.2022.116416>
- Douglas, M.R., Baisley, P., Soba, S., Kammerer, M.A., Lonsdorf, E.V., and **C.M. Grozinger**. “Putting pesticides on the map for pollinator research and conservation” *Scientific Data* (in press)
- Erickson, E., Junker, R.R., Ali, J.G., McCartney, N., **Patch, H.M.**, and **C.M. Grozinger**. “Complex floral traits shape pollinator attraction to ornamental plants” *Annals of Botany* mcac082, <https://doi.org/10.1093/aob/mcac082> (2022).
- Mathis, C.L., Neil, D.J., Lee, M.R., **Grozinger, C.M.**, Otto, C.R.V., and J. L. Larkin. “Can’t See the Flowers for the Trees: Factors Driving Floral Abundance within Early-successional Forests in the Central Appalachian Mountains” *Canadian Journal of Forest Research* <https://doi.org/10.1139/cjfr-2022-0014> (2022).

Quinlan, G.M., Sponsler, D., Gaines-Day, H.R., McMinn-Sauder, H.B.G., Otto, C.R.V., Smart, A.H., Colin, T., Gratton, C., Isaacs, R., Johnson, R., Milbrath, M.O., and **C. M. Grozinger**. “Grassy–herbaceous land moderates regional climate effects on honey bee colonies in the Northcentral U.S.” *Environmental Research Letters* 17:064036 <https://doi.org/10.1088/1748-9326/ac7063> (2022).

Erickson, E., **Grozinger, C.M.**, and **H.M. Patch**. “Measuring plant attractiveness to pollinators: methods and considerations” *Journal of Environmental Entomology* toac066, <https://doi.org/10.1093/jee/toac066> (2022).

Frizzera, D., Ray, A., Seffin, E., Zanni, V., Annoscia, D., **Grozinger, C.** and F. Nazzi. “The beneficial effect of pollen on Varroa infected bees depends on its effects on behavioral maturation genes” *Frontiers in Insect Science* vol 2, <https://doi.org/10.3389/finsc.2022.864238> (2022).

Dai, W., Yang, Y., **Patch, H.M.**, **Grozinger, C.M.**, and J. Mu “Soil moisture affects plant-pollinator interactions in an annual flowering plant” *Philosophical Transactions B* 3772021042320210423 <http://doi.org/10.1098/rstb.2021.0423> (2022).

Jones LJ, Singh A, Schilder RJ, **López-Uribe MM**. (2022) High parasite prevalence in the squash bees *Eucera (Peponapis) pruinosa* from the northeastern United States. *Journal of Invertebrate Pathology*.

Harvey J, Tougeron K, Gols R, Heinen R, Abarca M, Abram PK, Basset Y, Berg M, Boggs C, Brodeur J, Cardoso P, de Boer JG, De Snoo G, Deacon C, Dell JE, Desneux N, Dillon M, Duffy GA, Dyer L, Jacintha E, Espíndola A, Fordyce J, Forister M, Fukushima C, García-Robledo C, Gely C, Gobbi M, Hallmann C, Hance T, Harte J, Hochkirch A, Hof C, Kingsolver J, Lamarre GPA, Laurance W, Lavandero B, Le Lann C, Ma C-S; Ma G, Moiroux J, Monticelli L, Shah AA, Thakur MP, Thomas M, Van de Pol M, Verberk WCEP, Lehmann P, **López-Uribe MM**; Nice C, Ode P, Pincebourde S, Ripple W, Rowe M, Samways M, Sentis A, Stork N, Terblanche J, Tyljanakis J, van Baaren J, van der Putten W, Wagner D, Van Dyck H, Chown S, Wyckhuys K, Woods HA, Wetzel W, Weisser W. (2022) Scientists’ warning on climate change and insects. *Ecological Monographs* <https://doi.org/10.1002/ecm.1553>

Our team has created the following Extension Publications:

Hopwood, J., E. Rajotte, K. Gill, M. Vaughan, E. Lee-Mader, E. May, A. Code, N. Joshi, & **D. Biddinger**. 2021. Managing Eastern Apple Orchards for Pollinators and Other Beneficial Insects. Joint PSU and Xerces Society for Invertebrate Conservation publication. #AGRS-152G. Full color, 86-page guide with over 100 photographs.

Wilson, J., H. Austin, **D. Biddinger**, D. Epstein, T. Hiatt, A. Nielsen, E. Olson, M. Agtmael, and J. Walgenbach. 2022. Pollinator Best Management Practices for Apple. USApple Publication developed in partnership with the Honey Bee Health Coalition. 14 p. https://usapple.org/wp-content/uploads/2022/03/2022_03_18_USAPPLE_PollinatorReport_F.pdf

Anton, K. and **C.M. Grozinger**. “Honey Bee Management Throughout the Seasons”. Penn State Extension. 2022. <https://extension.psu.edu/honey-bee-management-throughout-the-seasons>

López-Uribe MM (2022) Pumpkins and Squash: What are their pollination needs?. Penn State Extension. Available online:

<https://extension.psu.edu/pumpkins-and-squash-what-are-their-pollination-needs?>

López-Uribe MM, Demchak K, Fleischer SJ, Bird S, Petitta I, Turley NE. (2022) Pollination of blueberry crops in Pennsylvania. Penn State Extension. Available online: <https://extension.psu.edu/pollination-of-blueberry-crops-in-pennsylvania>

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Scientists identify bee that can aid black cherry recovery

Black cherry historically has been one of the premier commercial hardwoods. It's used to make high-quality furniture, cabinets, paneling, flooring, musical instruments, and more. Nearly 30% of the nation's black cherry volume is in Pennsylvania.

Yet fewer seedlings and saplings have been reported growing in the last 20 years. Data from the U.S. Forest Service show a 60% decline in established black cherry seedling densities across the entire Allegheny Plateau, stretching across parts of New York, Pennsylvania, West Virginia, and Ohio.

Changing weather, soilborne pathogens, and insect pests likely contributed to the observed decline. Given that black cherry is insect-pollinated and unable to produce viable seed from self-pollination, a reduction in seed crops could be due to a pollination deficit. Identifying the pollinators and factors that influence pollinator abundance and specialization is critical for supporting and enhancing seed production.

Because the key pollinators of black cherry were unknown, it was difficult to develop management or conservation strategies to support and enhance viable black cherry seed production.

To identify the pollinators most responsible for transferring pollen needed for seed production, a Penn State research team conducted a two-year study in developed, semi-developed, and forested areas in Centre County and in the Allegheny National Forest near Kane, Pennsylvania. Methods involved visual observations, collecting insects that visited open flowers, testing seed viability, and examining the ecosystem's living and nonliving factors.

Researchers evaluated whether the pollinator community visiting black cherry was consistent across land-use types, tested different sampling approaches, and assessed floral specialization of insect visitors.

Although flies, beetles, and halictid bees—also called sweat bees—were frequent visitors to black cherry flowers during the study, the team discovered that the most important pollinator across the various landscapes was the andrenid or miner bee, a solitary, ground-nesting bee. Miner bees carried an average of 347 times more black cherry pollen than flies and 18 times more than halictid bees.

Another key finding was that the proportion of andrenids was significantly related to the proportion of viable collected seeds at both the Centre County and Allegheny Plateau sites. In other words, the more miner bees there were, the greater the chance for those seeds to grow.

We do not yet know very much about how to manage our landscapes to support andrenid bee species. The research team hopes their results will motivate more research in conserving pollinator populations in forest ecosystems and other landscapes.

The [research](#) appeared in the journal *Environmental Entomology*.

The Pennsylvania Department of Agriculture Hardwoods Development Council, the state Department of Conservation and Natural Resources Bureau of Forestry, USDA NIFA, and other funding supported this work.

 **Annual Report - Conifer improvement to increase Green Industry sustainability and resilience**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Douglas-fir (*Pseudotsuga menziesii*) and Fraser fir (*Abies fraseri*) are two of the most popular Christmas tree species grown in the eastern U.S. and comprise almost 70% of Pennsylvania's Christmas tree production acreage. However, these two species are becoming increasingly problematic and expensive to produce because of new pest species and escalating severity of established pests. Additionally, growers and consumers seek new species to fill niche markets and increase landscape diversity. This research addresses key areas of sustainability within the green industry, including evaluating alternative coniferous plant materials to ensure the selection of plants with exceptional landscape performance, improved stress tolerance and landscape resilience, reduced disease and pest incidence, and thus reduced pesticide usage.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

There is very little information available to growers relating to specific sources of Trojan fir, and Turkish fir that are suitable for use as Christmas trees. The Collaborative Germplasm Evaluation (CoFirGE) project has provided Christmas tree growers in the major U.S. production regions specific results regarding the growth rate, bud break profiles, hardiness, needle retention, and phytophthora root rot resistance characteristics for nearly 100 families of Trojan fir and Turkish fir. This research showed that Trojan fir tend to have faster growth rates than Turkish fir, and there was considerable genetic variation in the growth, quality, timing of bud break, and postharvest needle retention characteristic of the different sources of Trojan and Turkish fir. Turkish and Trojan firs tend to have earlier bud break than Nordmann fir, which can increase the potential for damage from late spring frosts and limit their potential use in some production regions. Unlike noble and Fraser firs, which tend to have excellent postharvest needle and moisture retention, these species also can exhibit significant postharvest needle shedding issues if they are allowed to dry. Current research is addressing a more comprehensive evaluation of additional sources of Turkish and Trojan firs to be able to make recommendations to growers on top-performing sources of these species that are adapted to regional production conditions and exhibit superior postharvest needle retention characteristics.

Many examples of healthy, low-maintenance Turkish fir and Nordmann exist in arboreta, botanic gardens, and university evaluation trials across the eastern U.S. Steps have been taken to compile information, site data, and images of these species in landscape settings. This information will serve as a database documenting the landscape performance of these underutilized *Abies* species. Resources are being developed to promote these promising species to conifer nurseries and the landscape industry at large.

Briefly describe how your target audience benefited from your project's activities.

Diseases, pests, and adaptability to regional environmental conditions can limit where Christmas tree growers can produce certain types of Christmas trees. For example, Phytophthora root rot limits where consumer-desirable species such as Fraser and noble fir can be grown. Several of these problems are related to site

conditions, such as poor drainage, elevation, late spring frost, etc., which is a major issue for growers who often have a limited land base on which they grow their crop. To address sustainability issues and remain competitive, industry leaders have indicated that the identification of disease and pest-resistant sources of trees with superior growth and postharvest characteristics that are adapted to regional production conditions is a top research priority. Research from this project has shown that Nordmann, Turkish, and Trojan firs have resistance to Phytophthora, Annosus root rot, and other stresses associated with hypoxic soils. Although susceptible to certain other biotic and abiotic problems, the severity of several disorders on Nordmann, Turkish, and Trojan firs is much less than that of Noble fir and Fraser fir. This is a promising result that has the potential to improve the business sustainability of Pennsylvania's Christmas tree farms.

One of the goals of the CoFirGE project is to identify individual top-performing trees that can be used to establish grafted clonal Turkish and/or Trojan fir seed orchards. Height growth, structure, and postharvest needle retention are important attributes that are used to identify top-performing trees. Seed orchards derived from the top-performing Trojan and Turkish fir are being established in Pennsylvania and other key Christmas tree-producing regions. Additionally, a germplasm repository for this resource has been established at the Rock Springs, PA, Penn State Horticulture Farm. This resource is extremely valuable and important for the scale-up of improved genetic lines of conifers for landscape and Christmas tree use.

This project has resulted in new and necessary collaboration between universities, the Christmas Tree Promotion Board, state Christmas tree associations, the Exotic Conifer Association, and individual growers, thus leveraging scarce research resources. Networking and communication between these stakeholders have also improved as a result of this project. Significant steps have been taken to develop and introduce Turkish fir, Trojan fir, and Nordmann fir as profitable Christmas tree alternatives to the disease-prone Fraser fir and Douglas-fir. Members of the research team have also made seed collection trips to the Republic of Georgia and Turkey, the native range of these three firs, and developed partnerships with key businesses to establish dependable seed supply chains for U.S. Christmas tree nurseries and growers. Extensive evaluations have been conducted to identify the best genetics, and ensure superior characteristics such as growth rate, postharvest needle retention, and tree form. Research trials also documented greatly improved disease tolerance, including high levels of resistance to Phytophthora root rot among these three fir species.

As a result of this research effort, seed and transplants of these disease-resistant species are more widely available to U.S. Christmas tree nurseries and growers. Conifer seed businesses in the U.S. are now able to import Nordmann and Turkish fir seed with more consistency and confidence. Retail lot survey data also shows strong consumer preference for these species due to their excellent foliage characteristics, as well as a higher price point compared to traditional Christmas tree species. Fraser fir growers in Pennsylvania now also have an important new tool in their fight against root rot diseases. Project research showed that mortality rates from Phytophthora root rot can exceed 90% for Fraser fir, whereas Turkish, Trojan, and Nordmann fir usually exhibit mortality rates of less than 25%.

Briefly describe how the broader public benefited from your project's activities.

This project has demonstrated the improved adaptability of Nordmann fir and Turkish fir as landscape species. This is an important step in the process of finding, evaluating, and promoting alternatives to the disease-prone species currently dominating the market, including Canadian Hemlock, Blue Colorado Spruce, Eastern White Pine, and Douglas-fir. Resources are being developed to distribute to conifer nurseries, and landscape industry stakeholders to communicate the advantages of increasing production of Turkish fir and Trojan fir. The U.S. Christmas tree industry relies on relatively few species to supply the seasonal Christmas tree market each

year. These species include Fraser fir, Noble fir, Douglas-fir, and a small handful of other pines, fir and spruce. The production costs for many of these species continues to rise due to insect and disease problems encountered by growers. Often this situation requires that growers utilize chemical control methods to protect their crop. The Christmas tree industry is seeking to develop new and/or improved conifer species requiring fewer inputs to produce a saleable tree. Advances in this direction by the industry will result in a much more sustainable and environmentally friendly production system. Ultimately this will also benefit the public at large, as the environmental footprint of Christmas tree production becomes smaller. In addition, the industry-research collaboration is focused on new species evaluation and introduction, which will provide consumers with a broader range of choices during the holidays.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Testing and developing new Christmas tree species resistant to diseases and adapted to changing climate

The U.S. Christmas tree market has typically been dominated by just a few species in each region. That has left the market vulnerable to disease and weather aberrations. Phytophthora root rot has been a problem for many growers. This is a fungus that enters the soil and can make a site basically unusable for Christmas trees. So growers are always looking for new species to try.

For about 12 years, Penn State researchers and colleagues from Connecticut, Michigan, North Carolina, Oregon, and Washington State have been seeking to identify, test, and propagate new conifer species that are resistant to disease and have desirable characteristics for Christmas trees, such as glossy soft needles and good needle retention.

They traveled to Turkey and the Republic of Georgia in Europe and identified some strong possibilities—Turkish fir, Trojan fir, and Nordmann fir—and collected seed to bring back to the U.S. After making sure that the seed was free of insect pests, they conducted lab and greenhouse studies of the species, and then planted about 30,000 trees on university research farms or cooperators' farms for one full cycle of growth—about 8 years. They measured parameters such as establishment, mortality, growth rate, and desirable Christmas tree characteristics. Species traditionally grown in a region were used as experimental controls for comparison.

They selected the very best individual trees and cloned them by grafting them on to good rootstock and planting a “clonal seed orchard.” This will produce seed that Christmas tree nursery growers can grow into seedlings for the cut Christmas tree market. The team is monitoring the seedlings for pests and diseases and developing region-specific management recommendations for how to grow these new species into the best possible Christmas trees in the shortest time. The new species should be available in the marketplace in about 5 years.

Another issue facing Christmas tree growers is that many of the species typically grown in the U.S. are native to cooler, more moist locations than where they are often grown commercially today. As the climate changes, this mismatch may become more of an issue, because Christmas tree fields are generally not irrigated. The three new species from Europe have greater tolerance for heat, sun, and drought. The researchers are also selecting for trees that break bud later in the spring to reduce susceptibility to late spring frost.

Besides working to “future-proof” the Christmas tree industry, Penn State woody ornamental tree researchers also work with Penn State Extension agents to provide educational programs to growers and answer growers' questions.

Funding comes from the Real Christmas Tree Board and the Pennsylvania Christmas Tree Growers Association, as well as USDA NIFA.

Critical Issue

Supporting Integrated Health Solutions

[Modulation of Inflammation in Health and Disease](#)

Project Director
Anthony Schmitt

Organization
Penn State
University Park

Accession Number
7000407



Annual Report - Virology section 2022 report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Coronaviruses, influenza viruses, paramyxoviruses, and other viral respiratory pathogens are capable of spilling over from wildlife into the human population to cause deadly pandemics. We aim to better understand the molecular biology of these viruses with a focus on learning how viruses evolve to transmit in humans and to develop new therapeutics and vaccines. We also aim to manipulate these viruses so that they can be re-purposed as gene therapy and protein delivery tools.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

We have gained new knowledge that will guide vaccination strategies for COVID-19 and influenza. We developed a new experimental approach to studying airborne transmission of influenza. We will use this approach to test intranasal vaccines. We also found that the immune response to SARS-CoV-2 is protective for at least 6 months; however, breakthrough infections still occur even when animals have high levels of antibodies.

We also advanced a new technology for protein delivery, based on paramyxovirus-like particles. We modified the composition of VLPs and their isolation procedure to achieve higher yields of delivery-capable particles. Efficient, high-yield particle production will facilitate the therapeutic use of the technology and its eventual commercialization.

Briefly describe how your target audience benefited from your project's activities.

The influenza transmission work was published in the journal mBio and our SARS-CoV-2 work was published in Emerging Microbes and Infection. Both journals have a broad audience and are top peer-reviewed infectious disease journals.

A continuation patent was issued by the USPTO for the VLP-based protein delivery work.

Briefly describe how the broader public benefited from your project's activities.

Coronaviruses, influenza viruses, and paramyxoviruses are among the viruses viewed as most likely to cause the next pandemic. We have contributed new knowledge that improves our understanding of viral transmission and that will aid in future

vaccination campaigns. CRISPR-based therapies have enormous potential for treatment of genetic diseases. We continue to negotiate with industry partners to license and further develop VLP-based protein delivery technology.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Publications:

1. Sutton TC*, Lamirande EW, Patel DR, Johnson KEE, Czako R, Ghedin E, Lee RTC, Maurer-Stroh S, Subbarao S*. Sequential transmission of influenza viruses in ferrets does not enhance infectivity and does not predict transmissibility in humans. *mBio*. 2022. Accepted. *Co-corresponding authors

2. Derr TD, James MA, Kuny CV, Patel DR, Kandel PP, Field CJ, Beckman MD, Hockett KL, Bates MA, Sutton TC, Szpara M. Aerosolized Hydrogen Peroxide Decontamination of N95 Respirators, with Fit-Testing and Virologic Confirmation of Suitability for Re-Use During the COVID-19 Pandemic. *mSphere*

3. Arora J, Patel DR, Nicol MJ, Field CJ, Jinpeng Wang, Nicole E. Froelich, Katkere B, Restori K, Terwilliger JA, Weaver V, Luley E, Kelly D, Kirimanjeswara, Sutton TC*, Cantorna MT*. Vitamin D and the ability to produce 1,25(OH)₂D are critical for protection from viral infection of the lungs.

Nutrients 2022 Jul 26;14(15):3061. doi: 10.3390/nu14153061.*co-corresponding authors

4. Belsler, JA, Lau, EH, Barclay, W, Barr, IG, Chen, H, Fouchier, RA, Hatta, M, Herfst, S, Kawaoka, Y, Lakdawala, SS, Yang Lee, LY Neumann, G, Peiris, M, Perez, DR, Russell, C, Subbarao, K, Sutton, TC, Webby, RJ, Yang, H, Yen, HL. Working group on the standardization of the ferret model for influenza risk assessment. *mBio* 2022 Jul 11;e0117422. doi: 10.1128/mbio.01174-22.

5. Field CJ, Heinly TA, Patel DR, Sim DG, Luley E, Gupta, SL, Vanderford TH, Wrammert J, Sutton TC. Immune durability and protection against SARS-CoV-2 re-infection in Syrian golden hamsters. *Emerg Microbes Infect* 2022 Dec;11(1):1103-1114. doi: 10.1080/22221751.2022.2058419.

Patents:

Schmitt, A., Ray, G., and Schmitt, P. Paramyxovirus virus-like particles as protein delivery vehicles. U.S. continuation US20190338253A1, Filed June, 2019. Issued January, 2022.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Delivery of CRISPR enzymes into cells has potential to cure diseases

Therapeutic proteins including transcription factors and genome editors have enormous clinical potential but are currently limited in part due to the challenges of safely and efficiently delivering these proteins to the interiors of target cells. A Penn State-led team has developed a new strategy for protein delivery based on manipulation of paramyxovirus genome packaging interactions.

The team began by studying the process of paramyxovirus assembly. These are human and animal viruses, including Newcastle disease virus, parainfluenza virus, and Nipah virus. The team learned how the virus genome is normally packaged into a virus particle, which spreads the virus to a new host. They used this information to determine how any beneficial protein can be packed into a virus particle in place of the virus's genetic material. They call these virus-like particles (VLPs) because they're not infectious. VLPs are vehicles to deliver proteins into cells.

The team worked with Penn State's Office of Technology Management and the Entrepreneurship and Innovation group in the College of Agricultural Sciences to patent the idea of using VLPs to transport material into cells. They are now finalizing a licensing agreement with an industry partner to commercialize the technology, which can deliver therapeutic proteins a patient lacks into cells, potentially curing disease.

The patented technology is what's known as a platform technology. It's versatile and can be directed toward many different applications.

The team's 2021 [paper](#) published in the *Journal of Virology* showed that it actually works—they were able to use VLPs to deliver various enzymes to target cells. One enzyme tested was Cre recombinase, which enters the cell nucleus, which is critical because this is where CRISPR enzymes function within the cell.

Currently, the best use of the VLP technology seems to be delivery of CRISPR enzymes into cells. If a disease is caused by a genetic mutation, researchers can try to fix the DNA sequence using genome editing, which is mediated by CRISPR enzymes. These are used to make directed changes to DNA.

After they license the technology, the research team will likely partner with the patent-holding industry group that has an animal disease model to help them fine tune the technique for that specific disease.

The research team is now trying to package base editors into VLPs. This is a variety of CRISPR that can change one nucleotide to another and may have the potential to cure disease by allowing correction of a defective gene.

This work was supported by the National Institute of Allergy and Infectious Diseases, USDA NIFA, Ximus Biosciences, and BioStrategy Partners Germinator program.

[Using \(meta\)genomics to improve food quality and safety](#)

Project Director
Jasna Kovac

Organization
Penn State
University Park

Accession Number
1015787



Annual Report - Using (meta)genomics to improve food quality and safety

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

This project aims to improve food safety by integrating omics and microbiology to:

1. Enhance the understanding of the foodborne pathogen epidemiology and improve accuracy of microbial subtype functional characterization using (meta)genomics;
2. Better understand factors governing pathogenic potential in *Bacillus cereus* group;

3. Characterize the associations between genetic and phenotypic antimicrobial resistance in foodborne pathogens;
4. Identify associations between production, processing and sanitation procedures and microbiomes/resistomes in the food supply chain and use this information to improve food safety.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

My research activities in the above-outlined areas resulted in scientific publications and research presentations at conferences, which resulted in significant progress towards the project goals.

Objective 1: Enhance the understanding of the foodborne pathogen epidemiology and improve the accuracy of microbial subtype functional characterization using (meta)genomics:

We collaborated with scientist in Ethiopia to determine the prevalence of *Campylobacter* and hygiene indicators in the dairy food supply chain in Ethiopia. We also reviewed the role of gender in dairy value chain in Ethiopia.

1. Mengstu, B., Tola, A., Nahusenay, H., Sisay, T., **Kovac, J.**, Vipham, J., Zewdu, A. (2023). Evaluation of microbial hygiene indicators in raw milk, pasteurised milk and cottage cheese collected across the dairy value chain in Ethiopia. *International Dairy Journal*. <https://doi.org/10.1016/j.idairyj.2022.105487>.
2. Admasie, A., Eshetu, A., Tessema, T.S., Vipham, J., **Kovac, J.**, Zewdu, A. (2022). Prevalence of *Campylobacter* species and associated risk factors for contamination of dairy products collected in a dry season from major milk sheds in Ethiopia. *Food Microbiology*. <https://doi.org/10.1016/j.fm.2022.104145>.
3. Garsow, A. V., Biondi, M. R., Kowalcyk, B. B., Vipham, J. L., **Kovac, J.**, Amenu, K., Zewdu, A., & Colverson, K. E. (2022). Exploring the relationship between gender and food safety risks in the dairy value chain in Ethiopia. *International Dairy Journal*, 105173. DOI: [10.1016/j.idairyj.2021.105173](https://doi.org/10.1016/j.idairyj.2021.105173).

Objective 2: Better understand factors governing pathogenic potential in *the Bacillus cereus* group:

We published a mini-review paper describing regulatory mechanisms governing the expression of *Bacillus cereus* group enterotoxins. The knowledge synthesized in this review paper is used as a basis for further experimental research focused on detecting genetic markers of *B. cereus* group cytotoxicity. In another review paper, we discussed recent paradigm shifts in the perception of the role of the bioinsecticide *Bacillus thuringiensis* in foodborne disease.

1. Prince, C., **Kovac, J.** (2022). Regulation of toxins associated with *Bacillus cereus sensu lato* toxicoinfection. *Applied and environmental microbiology*. DOI: [10.1128/aem.00405-22](https://doi.org/10.1128/aem.00405-22).
2. Biggel, M., Jessberger, N., **Kovac, J.**, Johler, S. (2022). Recent paradigm shifts in the perception of the role of *Bacillus thuringiensis* in foodborne disease. *Food*

microbiology 105. DOI: [10.1016/j.fm.2022.104025](https://doi.org/10.1016/j.fm.2022.104025).

3. Chung, T., Prince, C., Kimble, K., Salazar, A., Harm, G., Johler, S., & **Kovac, J.** (August 1, 2022). "Evaluating the relationship between presence of crystal protein-encoding genes, expression of crystal proteins, and cytotoxicity in *Bacillus cereus* s.s. isolates," 2022 IAFP Annual Meeting, International Association for Food Protection, Pittsburgh, PA, Accepted. International.
4. Kimble, K., Chung, T., Prince, C., Johler, S., & **Kovac, J.** (April 25, 2022). "Cytotoxicity analysis of *B. cereus* group isolates from diverse sources," BACT 2022, INRAE, Paris, France, Accepted. International.
5. Sullivan, E., Mills, C. E., & **Kovac, J.** (March 24, 2022). "Comparative analysis of *Bacillus cereus* group isolates' resistance using disk diffusion and broth microdilution and the correlation between antimicrobial resistance phenotypes and genotypes," Gamma Sigma Delta Research Expo, Penn State College of Agricultural Sciences, University Park, Accepted. Universities.
6. Kimble, K., Chung, T., Prince, C., & **Kovac, J.** (March 24, 2022). "Cytotoxicity analysis of *B. cereus* group isolates from diverse sources," Gamma Sigma Delta Research Expo, Penn State College of Agricultural Sciences, University Park, Accepted. Universities. **Poster award.**
7. Kimble, K., Prince, C., Chung, T., & **Kovac, J.** (November 13, 2021). "Cytotoxicity analysis of *B. cereus* group isolates from diverse sources," ABASM Annual Meeting, Allegheny Branch of American Society of Microbiology, Online, Accepted. Regional.
8. Salazar, A., *Chung, T., Harm, G., & **Kovac, J.** (November 13, 2021). "Evaluating the correlation between detection of crystal protein-encoding genes and expression of crystal proteins in *Bacillus cereus* s.s. isolates," ABASM Annual Meeting, Allegheny Branch of American Society of Microbiology, Online, Accepted. Regional.

Objective 3: Characterize the associations between genetic and phenotypic antimicrobial resistance in foodborne pathogens:

First, we studied the antimicrobial resistance of 85 diverse *Bacillus cereus* group isolates to assess whether disk diffusion and broth microdilution methods produce consistent results. Our results suggest that the disk diffusion method has inconsistent results with broth microdilution and should therefore be avoided. We further found a poor association between phenotypic antimicrobial resistance and known resistance genes, warranting further study of genetic mechanisms underlying phenotypic antimicrobial resistance in the *Bacillus cereus* group.

1. Mills, E., Sullivan, E., & **Kovac, J.** (2022). Comparative analysis of *Bacillus cereus* group isolates' resistance using disk diffusion and broth microdilution and the correlation between antimicrobial resistance phenotypes and genotypes. *Applied and environmental microbiology* 88(6), e0230221. DOI: 10.1128/aem.02302-21.

Objective 4: Identify associations between production, processing and sanitation procedures and microbiomes/resistomes in the food supply chain and use this information to improve food safety.

We studied the performance of two lactic acid bacteria in inhibiting *Listeria monocytogenes* in a monoculture, as well as in the environmental microbiome context. We used microbiomes collected from fruit packing facilities as well as from dairy facilities and found that the antilisterial activity of tested lactic bacteria is diminished in the presence of environmental microbiomes. These findings emphasize the critical role of microbiomes in the biological control of foodborne pathogens.

1. Sinclair, P., Rolon, M. L., Feng, J., Padín-López, A., LaBorde, L., **Kovac, J.** (2022). The ability of two lactic acid bacteria strains to inhibit *L. monocytogenes* by spot inoculation and in an environmental microbiome context. *Microbiology Spectrum*. DOI: 10.1128/spectrum.01018-22.
2. Mendez-Acevedo, M., Rolon, M. L., Sinclair, P., Macarasin, D., LaBorde, L. F., & **Kovac, J.** (August 1, 2022). "The effect of different sanitation treatments on the frequency of *Listeria monocytogenes* detected on non-food contact surfaces in apple packinghouses," 2022 IAAP Annual Meeting, International Association for Food Protection, Pittsburgh, PA, Accepted. International.
3. Rolon, L., Chandross-Cohen, T., Kaylegian, K. E., Roberts, R. F., & **Kovac, J.** (August 1, 2022). "Context matters: environmental microbiota of ice cream processing facilities affects the inhibitory performance of two lactic acid bacteria against *Listeria monocytogenes*," 2022 IAAP Annual Meeting, International Association for Food Protection, Pittsburgh, PA, Accepted. International.
4. Chandross-Cohen, T., Rolon, M. L., & **Kovac, J.** (March 24, 2022). "Isolation, Characterization, and Application of Anti-listerial Isolates in a Raw Milk Cheese Model to Inhibit *Listeria monocytogenes*," Gamma Sigma Delta Research Expo, Penn State College of Agricultural Sciences, University Park, Accepted. Universities. **Poster award.**
5. Rolon, M. L., Tan, X., Chung, T., Escalona, N., Chen, Y., Macarasin, D., LaBorde, L. F., & **Kovac, J.** (November 13, 2021). "Two-Year Monitoring of Environmental Microbial Communities in Three Apple Packing Facilities and their Association with the Presence of *Listeria monocytogenes*," ABASM Annual meeting, Allegheny Branch of American Society of Microbiology, Online, Accepted. Regional. **Poster award.**

Briefly describe how your target audience benefited from your project's activities.

My target audiences were:

- 4 graduate students and 8 undergraduate students that were trained through conducting research;
- 3 undergraduate researchers (involved in summer REU and REEU programs);
- PA tree fruit industry partners that were engaged in our *Listeria* control research and benefited from the research findings.

Briefly describe how the broader public benefited from your project's activities.

The broader public benefited from the project's activities by having open access to publications (listed above) and news articles:

<https://www.foodsafetynews.com/2022/05/penn-state-microbiologists-receive-usda-grant-to-study-biofilms-guarding-listeria/>

<https://www.psu.edu/news/research/story/research-team-gets-cdc-grant-strengthen-infectious-disease-surveillance>

<https://www.psu.edu/news/academics/story/gamma-sigma-delta-lauds-outstanding-college-ag-sciences-faculty-students-0>

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

NA.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Prevalence of *Campylobacter* species in dairy products in Ethiopia and risk factors for contamination

Campylobacter is among the leading bacterial foodborne pathogens, causing an estimated 550 million cases of gastroenteritis annually worldwide. Infections with *Campylobacter* can cause Guillain-Barré syndrome with symptoms of muscle weakening or paralysis.

In high-income countries, the incidence of campylobacteriosis is well documented through surveillance systems. But due to minimal surveillance systems for *Campylobacter* in low- and middle-income countries, the incidence of campylobacteriosis in African countries remains largely unknown.

The ingestion of contaminated food or water and direct contact with feces from infected animals are the main modes of *Campylobacter* transmission. Raw milk is the second most common source of *Campylobacter* infections, after chicken meat. The level of hygienic handling of milk throughout the value chain can affect the safety and quality of milk and dairy products.

Several research studies have examined the prevalence of *Campylobacter* among humans, livestock, and meat. A Penn State food scientist worked with an international team to fill the knowledge gap in the prevalence of *Campylobacter* and the potential exposure of the Ethiopian public to *Campylobacter* via consumption of milk and cottage cheese.

The team arranged the collection and sampling for *Campylobacter* of 912 dairy food samples from the establishments of 682 study participants, who were interviewed about their milk collection, processing, and retailing practices. *Campylobacter* was detected in 11% of tested food samples, which is significant particularly given that most milk is consumed raw in Ethiopia. All detected *Campylobacter* were *C. jejuni*. The highest prevalence of *C. jejuni* was found in raw milk (16%), followed by pasteurized milk (9%) and cottage cheese (2%).

The findings of this study can be used to develop food safety training and prioritize investments in the dairy value chain to improve dairy safety. Using warm water and soap to clean cow udders and teats before milking reduced the likelihood of detecting *Campylobacter* in milk. Filtering milk with a cloth, using a plastic filter, and storing milk in an aluminum container reduced the likelihood of detecting *Campylobacter* in milk at collection facilities. *Campylobacter* detection was significantly more likely in milk from collection centers with concrete floors. The odds of detecting *Campylobacter* in milk were 17 times greater in milk processing facilities that did not calibrate a pasteurizer annually. Having a separate refrigerator for milk storage reduced the odds of detecting *Campylobacter* at the retail level.

Given the prevalence of *Campylobacter* contamination in milk, awareness of the risks associated with consumption of raw milk should be raised regionally and nationally. Consumers should be encouraged to avoid consuming raw milk.

This [research](#) was published in the journal *Food Microbiology*.

The Bill & Melinda Gates Foundation and the UK Foreign, Commonwealth, and Development Office funded this work, along with contributions from USDA NIFA funds.

Closing Out (end date 07/11/2023)

[Genomic Interrogation of Foodborne Pathogens](#)

Project Director
Edward Dudley

Organization
Penn State
University Park

Accession Number
1015714



Final Report - 2022 Report

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Understanding of the routes of pathogen transmission requires the development of tracking methods that are capable of identifying organisms to the strain level. Once the ecology and spread within the food system is understood, principles of Hazard Analysis and Critical Control Points (HACCP) can be applied to identify pre-harvest and post-harvest control points, and to devise mechanisms for inactivating pathogens at these steps. Additionally, research directed at further understanding the biological basis of pathogen persistence along transmission routes is needed to devise evidence-based methods of decreasing the prominence of pathogens from farm-to-fork.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

We have sequenced large collections of the foodborne pathogen *Salmonella typhimurium* that originate from bird species and identified genetic markers that are predictive of isolates coming from this reservoir. We additionally compared these genome sequences to global databases and used this to assist the US Centers for Disease Control in identifying the source of a contemporary outbreak. We additionally have identified genes from the foodborne pathogen *E. coli* O157:H7 that are important for colonization of the recto-anal junction region of cattle, which is the main region these organisms adhere to and is believed to be the source of this organism that ends up on contaminated ground beef and vegetables. We have continued incorporating summer undergraduates from underrepresented groups into these programs. Over the summer of 2022, we hosted 12 undergraduates including 6 from the University of Puerto Rico-Aguadilla.

Briefly describe how your target audience benefited from your project's activities.

We have expanded our understanding of how genome sequencing can be used for identifying reservoirs of *Salmonella* Typhimurium, which is useful information for public health scientists. We have done this work in the context of advancing the careers of undergraduate students, especially those from underrepresented groups.

Briefly describe how the broader public benefited from your project's activities.

The public benefits through an increased safety to the food supply and a better educated and diverse pool of future food safety professionals.

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Antibiotic-resistant *Salmonella* strains not seen in migrating wild birds

Wild birds are known to be common reservoirs of *Salmonella*, a pathogen that sickens millions of people every year. Scientists have worried that wild birds carrying antimicrobial-resistant *Salmonella* pose a risk to public health because they could spread the resistant bacteria across large areas in a short time.

Penn State researchers and their colleagues sequenced the whole genome of 375 *Salmonella enterica* strains from wild birds collected in 41 U.S. states from 1978 to 2019 to examine bacterial resistance to antibiotics and heavy metals. Their work answers important questions about the role migrating birds play in transmitting diseases to humans.

The team had expected that *Salmonella* in wild birds—like the bacteria we can isolate from domesticated farm animals—would carry large numbers of antimicrobial-resistance genes. But they found the opposite to be true. Although many wild birds carry *Salmonella*, the strains of the bacteria they convey usually do not harbor antimicrobial-resistance genes. This research indicated that wild birds do not serve as important reservoirs of resistant *Salmonella enterica* strains.

The research results showed that Typhimurium was the dominant *Salmonella enterica* strain, accounting for 68% of the bird isolates. However, less than 2% of those isolates were identified as multi-antimicrobial resistant or resistant to heavy metals. All the multi-resistant *Salmonella enterica* were isolated from water birds or raptors; none of them was isolated from songbirds.

The isolates tested in the study came from the National Wildlife Health Center, which is part of a U.S. Geological Survey lab. The center has a collection of *Salmonella* isolates amassed over more than 40 years from sick migratory birds.

Further analysis of this genetic collection showed that certain strains of *Salmonella* were associated with specific hosts. For example, after sequencing 131 *Salmonella* Typhimurium isolates from wild birds collected in 30 U.S. states, they found that songbirds and waterbirds were likely to host the same strains, while gulls and terns carried distinct, different lineages of the bacteria. This indicates that *Salmonella* Typhimurium may have undergone evolution within wild birds in the U.S.

The researchers also showed that lineages formed by wild bird isolates differed from most isolates originating from domestic animal sources. They were able to attribute Typhimurium genomes to various groups of wild birds. That's important because identifying host-adapted genomic data sets can improve source prediction and facilitate future disease outbreak investigation.

This work was published in [Environmental Microbiology](#) and in [Applied and Environmental Microbiology](#).

In addition to USDA NIFA funds, the U.S. Food and Drug Administration provided funds for this research.

Closing Out (end date 07/11/2023)

[Linking food composition to food choice and nutrition: Understanding consumer perception and attitudes from a compositional, functional, and sensory point of view](#)

Project Director	Organization	Accession Number
Helene Hopfer	Penn State University Park	1013412



Final Report: Linking food composition to food choice and nutrition

Final Result

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

As food choice is the result of both external cues and individual preferences, informed by previous experiences and genetic make-up of the human being, it is critical to understand how food composition, function, nutrition, and sensory link to individual perception, acceptance, and intake. The goals of this project are to develop methods and tools to link food choice to food function by studying the impact of food composition, and sensory properties on perception, consumer acceptability and food intake. Specific objectives of this projects are:

- 1) To link individual perceptual differences, preferences and intake to the composition, and sensory properties of foods and food ingredients with human sensory methods.
- 2) To determine the impact of crop genetics on food composition, nutrition, and sensory properties, and to study the combined effects of crop genetics, growing conditions, postharvest practices and food processing on these properties.
- 3) To study the complex interactions of individual food ingredients on the overall perception, nutrient content, and acceptability of food.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Our main activities are focused on several areas: (1) understanding the importance of flavor along the cacao supply chain, from tree to bean to bar to consumer, (2) utilizing taste-aroma cross-modal interactions as a sugar-reduction strategy for dairy drinks, (3) elucidating external and compositional factors affecting wine flavor perception, and (4) modelling flavor release from novel starch-flavor inclusion complexes with instrumental and human sensory methods.

The following experiments were conducted and reported:

- 1) We demonstrated that significant differences in fat content, volatile and non-volatile composition exist across cocoa cultivars grown in the same location and different seasons. We further found these cultivars respond differentially to

environmental conditions, as assessed over three different harvest seasons. We also demonstrated fermentation has a significant effect on chemical composition and sensory perception of cacao beans and we could also show that cacao from different origins and roasted in the same way showed significant difference in sensory perception of bitterness and liking. Taken together, these results demonstrate the flavor of processed plant foods is the result of many factors, including plant genetics, growing conditions and origin, as well as post-harvest processing operations, linking compositional changes to differences in human perception. (Goals 1 and 2)

This project also studied consumer perception of fine flavor and craft chocolate. Using a mixed-methods approach, we found that consumers segment chocolate products in terms of quality based upon usage occasion rather than cost or other factors, with use of segmentation, price, availability, and packaging as quality determinants. They desire credence attributes that convey trust and seek out experience attributes such as utility and/or joy. (Goal 3)

2) Cross-modal interactions between an aroma and sucrose were found to increase in perceived sweetness in dairy drinks of increasing complexity. We found that the magnitude of this effect was dependent on the task, specifically, the mental strategy adopted by human participants. Results address goals 1 and 3, as we were able to link changes in sensory perception of food-relevant attributes (e.g., sweet taste, vanilla flavor, cocoa flavor) as well as liking and acceptability to systematic changes in food composition. Using this strategy a sugar reduction of up to 30% can be realized without significant drops in acceptability through cross-modal interactions as a compensation mechanism. (Goals 1 and 3) We found that storage conditions affect the aroma of roasted coffee beans differently, dependent on roasting treatment, but not coffee knowledge and expertise. Similarly, we were able to demonstrate that beliefs and values of consumer significantly impact food choice, and vice versa. (Goal 3)

3) We were able to determine the impact of regionality and cultivar on consumer perception of PA wines, through analytical sensory science (descriptive analysis) and through an online consumer conjoint analysis experiment. We found that consumers who have tasted a lesser known hybrid variety prefer the presence of that varietal name on the wine label over a more generic "white wine" label text previously. These results address specific goals 1 and 3, as we studied how wine compositional factors affect perception and how external information presented on a wine label affects consumer perception of lesser known wine varieties and wine regions. (Goals 1 and 3)

4) Novel starch-flavor inclusion complexes were characterized for their ability to deliver flavor agents over a longer period of time, extending flavor perception, as measured by in vivo human sensory and in vitro instrumental methodologies. Using two different flavor compounds, we were able to show that flavor release differed substantially from the control treatment, and also that flavor release is compound-dependent. We also showed that individual variability in saliva composition impacts this flavor release over time, as well as the application of these starch inclusion complexes in other foods. These results address Goals 3 and 4, as these starch inclusion complexes could be used as novel flavor delivery systems. Understanding the temporal release mechanism and the effect of the release kinetics on human perception is critical in assessing the potential of these complexes in food. (Goals 3 and 4)

Briefly describe how your target audience benefited from your project's activities.

Activities supported by this project reach the following target audiences: (i) stakeholders involved in research, development, and marketing of new and existing food products and ingredients, (ii) researchers, scientists, and educators involved in research and dissemination of information related to linking food composition to food choice and nutrition, and (iii) the general public who wish to make informed decisions about food choices. To the scientific communities through peer-reviewed articles, poster and oral presentations, and editorial service. To undergraduate and graduate students through lectures, research mentoring and committee work.

Briefly describe how the broader public benefited from your project's activities.

The general public benefited from this project through experiential learning activities and outreach events on chocolate making, sensory and consumer science, and flavor chemistry - these activities were provided both in-person and in a remote format due to the COVID-19 pandemic. Additionally, results were disseminated in several open access research papers, press releases, talks, workshops, and short courses.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

One-on-one mentoring and training was provided to nine graduate students and seven undergraduate students in the fields of sensory and consumer science and flavor chemistry. In addition, graduate students and the PI attended and participated in scientific conferences with oral and poster presentations.

Disseminated Work

Peer-reviewed Articles

- 1) Farcuh M & Hopfer H (2023) Aroma volatiles as predictors of chilling injury development during peach (*Prunus persica* (L) Batsch) cold storage and subsequent shelf-life. *Postharvest Biology and Technology* **195**: 112137. DOI: 10.1016/j.postharvbio.2022.112137
- 2) Hopfer H, Riak AC, Roberts RF, Hayes JE, & Ziegler GR (2022) Synergistic and antagonistic ingredient interactions as a sugar reduction strategy in chocolate milk. *Journal of Sensory Studies* **37**(5):e12770. DOI: 10.1111/joss.12770
- 3) Goza JL, Ziegler GR, Wee J, Hayes JE, & Hopfer H (2022) Salivary a-amylase activity and flow rate explain differences in temporal flavor perception in a chewing gum matrix comprising starch-limonene inclusion complexes. *Food Research International* **158**:111573. DOI:10.1016/j.foodres.2022.111573
- 4) Elder AS, Coupland JN, Hopfer H, & Elias RJ (2022) Effect of alkyl chain length on the antioxidant activity of alkylresorcinol homologs in low-moisture crackers. *LWT* **164**: 113637. DOI: 10.1016/j.lwt.2022.113637
- 5) McClure AP, Hopfer H & Gruen IU (2022) Optimizing consumer acceptability of 100% chocolate through roasting treatments and effects on bitterness and other important sensory characteristics. *Current Research in Food Science* **5**:167-174. DOI: 10.1016/j.crf.2022.01.005

Theses & Dissertations

- 1) Meneses Marentes NA (2022) Effect of Cocoa Sweatings and Time of Fermentation on Flavor Compounds and Sensory Perception of Cocoa. MS Thesis, The Pennsylvania State University.

- 2) Goza JL (2022) An Instrumental and Sensory Characterization of V-Type Starch-Aroma Compound Inclusion Complexes. PhD Dissertation, The Pennsylvania State University
- 3) Alden RC (2021) Synergistic And Antagonistic Ingredient Interactions As A Sugar Reduction Strategy In Chocolate Milk. MS Thesis, The Pennsylvania State University
- 4) Brown AL (2021) Understanding Flavor in Fine or Flavor Theobroma Cacao: A Multidisciplinary Human Subjects Research Approach. PhD Dissertation, The Pennsylvania State University
- 5) Gutierrez I (2021) Phytochemical composition and bioactivity of clove (*Syzygium aromaticum*) oil and post-distillation biomass extract. MS Thesis, The Pennsylvania State University
- 6) Chrisfield BJ (2020) The Effects of Copper-Based Fungicides on The Quality and Performance of Hops. PhD Dissertation, The Pennsylvania State University
- 7) Keller ST (2020) Examining Regional Trends in Pennsylvania Grüner Veltliner Wines Using Instrumental and Human Sensory Methods. MS Thesis, The Pennsylvania State University
- 7) Donohue MJ (2020) Understanding Regional Sensory Profiles of White Wines in Pennsylvania. MS Thesis, The Pennsylvania State University
- 8) Poveromo AJ (2019) The impact of wine matrix components on the static and temporal perception of sensory attributes in a white, hybrid model wine. MS Thesis, The Pennsylvania State University
- 9) Wang G (2018) Taste-aroma interactions as a sugar reduction strategy in flavored milk. MS Thesis, The Pennsylvania State University

Impact Statement (Optional)

Use this space to talk about the impact that this result had, in layman's terms. Adding comments here will **not** change the content in the highlighted result.

Roasting cacao beans longer helps increase the acceptability of unsweetened chocolate for dark chocolate-loving consumers

Many people love dark chocolate and have heard that it might have some health benefits, but wonder if “healthy” chocolate can taste good. Dark chocolate is high in flavonoids, which are considered functional ingredients that produce beneficial health effects. However, to make chocolate more appealing, it is usually sweetened to mask the cacao bean’s inherent bitterness and astringency.

A team of food scientists took a novel approach to studying bitterness perception and consumer acceptability of 100% chocolate (with no sugar) by using sensory evaluation to examine the variation of cacao-related bitterness as a function of roasting and cacao origin. The study involved 27 100% chocolates made from cacao beans roasted at various intensities and 145 people who came to the 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.

Confection makers who want to develop products containing 100% chocolate for dark chocolate-loving consumers can reduce bitterness and optimize consumer acceptance by roasting cacao beans longer and at higher temperatures.

Scientists’ understanding of the variation of cacao-related bitterness has historically come from instrumental investigation of the bitter compounds found in cacao beans, but this research is new because of its use of sensory evaluation to quantify this variation and link it to overall consumer liking.

This [work](#) was published in *Current Research in Food Science* and supported by the Professional Manufacturing Confectioners Association and USDA NIFA funds.

Not Provided

Report Status

Approved as of 06/28/2023

Comments

The Pennsylvania State University 2022 Annual Report of Accomplishments and Results covers activities by the Pennsylvania Agricultural Experiment Station (AES) and Penn State Extension (PSE). The Executive Summary gives a general overview of the conceptual framework developed around agricultural sustainability and integrates both natural and social sciences and considers the impacts and synergies of both rural and urban landscapes.

While the updates to the Merit and Scientific Peer Review Process are comprehensive on the nature and objectives of the internal and external panels, they lack details on timeline of reviews. The Stakeholder Input Process is unchanged but remains appropriate.

Six critical issues were addressed in the research and extension programs: (1) Advancing Agricultural and Food Systems; (2) Building Community Resilience and Capacity; (3) Developing Biologically Based Materials & Products; (4) Fostering a Positive Future for Youth, Families, & Communities; (5) Promoting Environmental Resilience; and (6) Supporting Integrated Health Solutions

The Critical Issues and Highlights section could benefit from more details and data to highlight the overall impact on these programs (similar observation noted regarding the 2021 annual report). The collaborative nature of several projects is commendable. One example is a collaboration between Penn State researchers and Virginia Cooperative Extension to offer a webinar on mushroom varieties and production.

Of importance as well is designing programs to benefit youth. One such example highlighted in the report is the collaboration of the Farm Safety Extension team on the Leader's manual for the National Safe Tractor and Machinery Operation Program.

Work on invasive species is noted. Results from a project on impacts of spotted lanternfly (SLF) on tree ecophysiology are expected to help nursery and forest managers manage this pest at appropriate times.

The report included information on 132 research projects, 30 extension projects, 30 integrated projects, and 41 multistate projects. The broad range of these projects is commendable as well as the focus on benefiting stakeholders. Noted was that 78% of research projects highlighted came from critical issues 1 and 5. It is not clear from this report why the research emphasis is mostly focused on only two critical issues and whether there are technical advancements and knowledge to be learnt within the other critical issues.

The report is a clear and comprehensive.

Appendix

Research Projects 

Extension Programs 

Other Projects / Programs 
