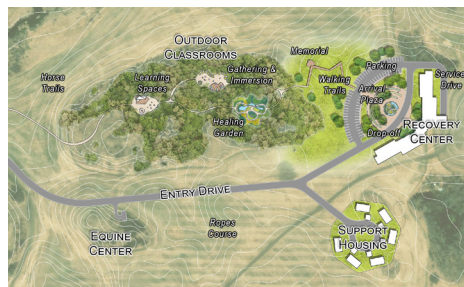
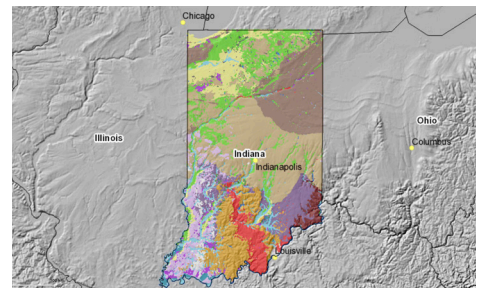


# Purdue Fundamental and Applied Research and Extension Showcase

Bringing World-Class Education, Life-Changing Research to Rural and Urban Communities

September 16, 2021



PURDUE UNIVERSITY

College of Agriculture



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- *Purdue Rainscaping Education Program*
- *Steve McKinley*
- *Darrell Schulze*

## Foreword

Compiling an annual report that captures the impact of Purdue research and Extension accomplishments, outcomes and activities is time-consuming and tremendously rewarding, bringing great pride and satisfaction.

These stories reveal the breadth and scope of our outreach and demonstrate the measures taken to bring Purdue's world-class innovation and expertise to the urban, suburban, and rural areas where they're needed most. Some examples include:

- Sorghum gene discovery and trait development for livestock feed.
- Advancing the sustainability of weed management across the landscape.
- Modeling and visualization tools for water management.
- Producing crops effectively and economically in controlled environments.
- Engaging family forest owners in the effort to reduce invasive plant spread.

Extension specialists and educators deliver educational programs and research-based knowledge that, especially in challenging times, help families, individuals, and communities cope, prosper and thrive. Here are some of their efforts:

- Facing mental health and building support in the community.
- Helping Indiana adults take control of their personal finances.
- Through 4-H, encouraging teens to grow in leadership.
- Food safety training for high school students.
- Workshops to build cultural competence for Hoosiers.

Our combined efforts meet the changing needs of residents in every Indiana county as well as across this nation and around the globe. We hope you'll find this compilation interesting and helpful as you communicate with stakeholders about potential collaborations.

Many helped us craft this document. Together, we do great things. We appreciate every individual's assistance in this effort.

*Jason Henderson, Senior Associate Dean and Director of Purdue Extension, Purdue University*

*Bernie Engel, Senior Associate Dean and Director of Agricultural Research and Graduate Education,  
Purdue University*

## Acknowledgements

Groundbreaking, multidisciplinary research that addresses society's most pressing challenges has long been a hallmark of Purdue Agriculture, Veterinary Medicine and Health and Human Sciences. Even during a global pandemic our efforts have brought vital information and resources from the laboratory and classroom to cities and towns in Indiana, across our nation and around the world.

This report spotlights our work in Agriculture, Horticulture and Natural Resources; Food, Nutrition, Families and Health; Youth Development; and Community and Business Development. Here are a few examples of our impactful projects:

- Focusing on water management, with modeling and visualization tools.
- Designing tools and autonomous systems to increase productivity and efficiency while maintaining profitability.
- Creating viable solutions for the future of agricultural equipment, including electrified tractors, to greatly reduce the energy consumption and environmental impact.
- Enhancing the competitiveness and value of U.S. beef.

Our land-grant mission challenges us to build a sustainable future for our local communities, our state and beyond.

I thank Jason Henderson, Senior Associate Dean and Director of Purdue Extension, and Bernie Engel, Senior Associate Dean and Director of Agricultural Research and Graduate Education, for their leadership, and all of the faculty, researchers, specialists, educators, staff and volunteers who tirelessly discover and deliver unbiased information and resources.

*Karen Plaut, Glenn W. Sample Dean of Agriculture, Purdue University*

Purdue Extension plays a starring role in our university's efforts to put science into practice.

For decades Indiana residents have regarded Extension as a trusted advocate. Our faculty, specialists and educators work closely with communities and stakeholders, creating lasting collaborations and partnerships that address important opportunities and concerns, focused on enhancing and enriching the quality of life in our state.

Today's Extension uses 21st century tools to assist people where they live and equip them with life-changing education, knowledge and support.

During such challenging times, the work of Extension is even more important – and the benefits are available to all. We want to ensure you can take full advantage of these benefits. The stories in this showcase of accomplishments present powerful examples of how we bring our fundamental and applied research to help communities, farms, and businesses become healthier and stronger, and enhance the lives and livelihoods of people throughout the state, this nation and the world.

*Jay T. Akridge, Provost and Executive Vice President for Academic Affairs and Diversity, Purdue University*

## Agriculture

### Farm Management

#### **Management advances and increased revenue for Midwest women in agriculture**

More than 1.1 million U.S. farms have women listed among the producers. In Indiana, even with farm numbers declining and average age of farmers increasing, the number of women farmers has increased by 30 percent since 2012. Indiana farm women are taking larger roles in managing and owning farming operations.

Purdue Extension leads the annual Midwest Women in Agriculture Conference, which addresses educational needs of women employed in or involved with agriculture. At the 19th annual two-day conference, nearly 140 attendees, speakers, and sponsors gathered to learn about succession planning, farm management, leadership, managing livestock, and health and well-being.

A pre-conference program, Becoming the Employer of Choice, addressed how to improve human resource management skills. Topics included developing a motivated workforce, hiring the right people, farm business culture, on-boarding, reviews and feedback, and managing conflict. During the conference, the 7th Young Ladies in Agriculture Forum provided networking opportunities for 78 high schoolers to learn about agriculture careers and opportunities.

Afterward, three-fourths of attendees reported that they gained useful resource materials and names of contacts. More than half felt the conference was very important to their operation, business or future career choices. A majority expressed plans to do things differently, including getting ideas in place to make transitions easier as farms grow and expand, doing a better job at succession planning, and applying skills to work with 3rd, 4th and 5th generations on the farm. Also mentioned were working with farmers on land-leasing options, advocating more for agriculture, and using new management skills for hiring.

Attendees reported actions taken since last year's conference. One-third had updated their succession or estate plan. Others had started new businesses to add income, increased agriculture advocacy efforts, implemented farm business changes to increase profitability, and volunteered for leadership in their community. One attendee shared that their farm business increased revenue potential by more than \$10,000 as a result of their conference participation.

From Becoming the Employer of Choice, participants learned important lessons for getting employee ideas, working on goals, being intentional in creating on-boarding procedures, and assessing attitudes and thinking through conflict situations before responding.

High schoolers were motivated to work on their goals and said they felt informed about college majors in agriculture. Those in the Young Ladies forum interacted with farmers, agriculture industry advocates, college students, and others, and plan to engage with these connections and resources for future guidance.

The Conference is extremely important to Indiana farm women to learn and make connections that contribute to management advances and increased revenue for their operations.

#### **On-Farm readiness reviews and mock audits keep Indiana producers in business**

The recent Food Safety Modernization Act and the Produce Safety Rule by FDA are regulations requiring growers to produce fruits and vegetables without undue risk of contamination. In preparation for new Indiana Department of Health farm inspections to ensure grower compliance, Purdue Extension arranged for On-Farm Readiness Reviews as developed by the National Association of State Departments of Agriculture.

A 3-member team from Extension, the Indiana State Department of Agriculture, and the Indiana State Department of Health inspector who will do the official farm inspection, visits farms for two-hour interviews and tours. The team observes growing conditions, harvesting practices, packinghouse operations, and water sources. At the end, the team provides suggestions to improve food safety practices and educational resources to assist with solutions for achieving compliance. Since the new regulations and instructions, a total of 17 reviews have been conducted.

For producers moving into wholesale or increasing sales, Extension conducts Mock Audits to help growers prepare for third-party audits, a buyer-driven industry requirement. Helping growers pass these audits assists them in gaining access to new or additional markets. Six Mock Audits have been completed.

During the pandemic, Reviews and Mock Audits did not resume until July. Precautions were taken with team members wearing face coverings, maintaining a distance of six feet, and meetings and discussions being held outside where adequate space for separation existed.

Since produce farm inspections began in 2019, all farms that had completed the Review passed inspection and were found to be in compliance with regulations. All producers who had Mock Audits passed their official industry-required audit and moved ahead with expansion of their operations. These Reviews and Mock Audits have helped Indiana operations meet regulations and requirements for safe produce production.

## Crops

### **Sorghum gene discovery and trait development for livestock feed: Gene discovery and functional validation in sorghum**

Sorghum breeders are developing high-yielding cultivars for commercial forage production systems, but tremendous opportunities remain for improving the nutritional value of sorghum forage. One such issue is the production of dhurrin, a cyanogenic glucoside of sorghum that can be detrimental to livestock if consumed in sufficient quantities.

A novel dhurrin-free sorghum technology has been developed at Purdue University to help farmers manage the risk of dhurrin production in forage sorghum. The Purdue sorghum breeding program identified and patented a genetic mutation in CYP79A1 (C493Y) that disrupts the production of dhurrin (Tuinstra MR, Krothapalli K, Dilkes B, Buescher E. Genetic Mutations that Disrupt Dhurrin Production in Sorghum U.S. Patent No. 9,512,437. Issue Date: December 6, 2016). After discovering this mutation, researchers began crossing and backcrossing this mutation into sorghum parent lines to produce commercial hybrids. Two pollinator parents and an A-line and B-line pair were developed to produce a dhurrin-free sorghum-sudan hybrid and forage sorghum hybrid.

Purdue University and commercial partners at AgAlumni Seed Company announced a partnership with S&W Seed Company to provide the first dhurrin-free sorghum forages in the commercial seed market. Production of dhurrin-free hybrids will simplify pasture and forage management by providing sorghum growers with an effective management system to get the most from every production acre.

This project has enabled discovery of a gene that is contributing to sorghum lines with desired functional characteristics and the creation of novel hybrids for livestock feed.

### **Advancing the sustainability of weed management across the landscape: Controlling weeds for natural resources and agricultural systems**

Among weed scientists, there is an increasing recognition of the need to incorporate weed ecology into management decisions and to examine alternate non-herbicide tools and strategies to achieve greater sustainability for weed management.

The overall goal of research was revising the management strategies based on a more thorough understanding of weed ecology and herbicide resistance so that weed control can be improved, inputs optimized, and selection pressure for herbicide resistance reduced.

Field research evaluated effectiveness of Liberty Link (glufosinate-resistant) and Xtend (dicamba + glyphosate-resistant) soybeans for improving tall waterhemp weed management. Using glufosinate and dicamba integrated with other effective herbicide site of action groups shows promise to help growers control tall waterhemp. However, tall waterhemp's potential to evolve resistance is significant if best management practices are not used incorporating diverse herbicide combinations and non-chemical weed management tactics.

As an alternative to chemical weed control, researchers purchased a high-residue, row cultivator used in conventional and organic production systems. Researchers demonstrated this cultivator at Throckmorton-Purdue Agricultural Center (TPAC) with good results, but a grower must be accepting of some weed survival, especially within the crop row.

Cover crop management strategies were also evaluated for potential to improve control of herbicide-resistant weeds in corn and soybeans. Cover crops integrated with traditional herbicide use controlled winter and summer annuals



weeds that emerge early in the spring. However, very little benefit was observed with weeds that emerge later in the spring. Poor management of cover crops such as failed or delayed spring termination resulted in lower crop yields and interference with herbicide efficacy.

The research established new knowledge on weed ecology and strategies (herbicides and non-chemical alternatives) to control weed growth, including herbicide-resistant populations.

### **Corn, soybean and environmental responses to integrated 'cropping systems' that are potentially more stress-resilient**

Lack of diversity in crop rotations and intensive tillage practices (primarily before corn in rotation) impair both field crop productivity and soil quality. Overall sustainability of corn production in the Midwest can be enhanced via continuing refinements of management systems and by achieving better scientific understanding of underlying reasons for genotype by environment by management (G x E x M) interactions as climate and crop inputs or equipment change.

This cropping systems research was to enhance agronomic efficiency, climate-change resiliency and environmental sustainability of corn production. A major focus was placed on the assessment of modifications to no-till practices for their effectiveness in enhancing corn growth while conserving soil quality in corn (following either corn or soybean) and assessment of greenhouse gas emissions, and especially nitrous oxides (per unit yield and per unit plant N uptake) associated with integrated conservation tillage and N fertilizer management systems in high yield corn production systems.

The long-term tillage and rotation experiment, in place since 1975, was one of 124 long-term experiments across North American chosen for the Soil Health Assessment under a Noble Foundation and FFAR grant. Detailed soil measurements were taken on soil samples collected in April 2019. Tillage treatments (mostly in place since 1975) consisted of no-till (NT), strip-till (ST), chisel plow (CP), and moldboard plow (MP). All yield data are accessible via a Dashboard and confirmed: continued good performance of strip-till regardless of rotation system, equal yields of no-till to conventional tillage in corn-soybean rotation, and continued substantial yield gains of corn when grown in rotation with soybean instead of in continuous corn.

Greenhouse gas emissions were measured from 2015 to 2017 from tillage and nutrient management experiments and revealed consequences of tillage and nutrient management for nitrous oxide losses per unit area, per unit yield. Plots were measured for nitrous oxide emissions and whole-plant N recovery in corn to express greenhouse gas losses relative to recovery efficiency of N fertilizers for that environment, soil, hybrid and management combination.

This project provides new knowledge on the use of cropping systems for environmental sustainability, climate resilience, and agronomic efficiency.

## **Digital Ag**

### **Machine systems and automation for increasing productivity and efficiency of crop production**

New technologies allowing increased productivity and efficiencies are critical components of a sustainable future. Increased adoption of autonomous systems and improved data analytics are examples of approaches that will be needed to meet future food production demands.

The major goal of this work was to create new autonomous and precision agricultural technologies that can be leveraged to help meet global food demands.

An autonomous unloading system for combine-to-grain cart grain transfer was developed with John Deere. The system leveraged existing John Deere technologies and a perception system to autonomously control material flow and relative positions of the two machines. This technology has the potential to increase harvest efficiency and reduce operator stress/fatigue.

Development has continued toward an Excel-based energy and techno-economic model for row crop farming operation. The model allows users to enter operational data such as farm size and desired operational weather windows, and returns the most energy and cost-efficient equipment selections using real-world tractor test data. The model also allows for addition of custom machinery, which will be used to understand the potential impacts of autonomy on farming operations.

A modular autonomous research platform was designed to aid agronomic researchers in high-density, in-field sampling. The base platform was designed to carry modular sensing platforms, navigate to sampling point in standing crop, and carry sensor payload. This platform will allow for agronomic researchers to conduct experiments requiring high-density field sampling such as soil moisture model validation and soil carbon research that is currently unfeasible to complete using manual sampling.

These tools and autonomous systems have a chance at increasing productivity and efficiency while maintaining profitability through reducing the labor burden felt by many operations.

### **Analysis of energy efficient solutions for modern agricultural machines**

Current state-of-the-art technology of tractor-implement hydraulic systems have overall energy efficiencies of ~25% or less. However, there is a tremendous opportunity to significantly increase this low energy efficiency through a re-design of the hydraulic control system.

This research involves formulating, designing and demonstrating a novel energy efficient architecture for the actuation system of future generations of agricultural tractors using hydraulic functions. Focus is on the actuation system for tractor suspensions, steering, hitches and remotes, which is commonly based on high-pressure hydraulic control technology. This system is particularly inefficient when implements (such as planters, bailers, etc.) are powered through hydraulic remotes.

A tractor (New Holland T380) and a 16-row planter (Case Earlyriser) were provided to Purdue by Case New Holland (CNH) as reference case of study. This choice was made considering the power level (a planter is one of the most energy-demanding implements) and the wide use of such class of equipment among U.S. farmers. Both the tractor and the planter were instrumented and tested at Purdue to validate proper numerical techniques used in this project to evaluate the impact of modification to the hydraulic system. The models were formulated with significant data provided by CNH and Bosch Rexroth, and achieve a high level of accuracy with respect to the experimental results.

The project has proposed different alternative architectures, some involving minor modifications to the commercial solution (the most significant involving advanced electro-hydraulic control strategies) some involving more radical changes to the hydraulic control system. The most innovative solution is represented by the so called "multi pressure rail", which transforms the system from a flow-controlled architecture, as in the commercial solution, to an advance pressure-controlled one. Simulations of these solutions has shown great advantages in terms of the energy efficiency of the hydraulic system, bringing its energy efficiency from 25% to about 40%, for the incremental solutions that can be implemented with existing technology, and slightly above 50%, for the more innovative multi-pressure rail solution.

An important aspect of this research involved formulating proper utilization cycles for the reference machines, as standards for the high-pressure hydraulic system of agricultural equipment is not sufficient to drive dedicated studies aimed at quantifying their energy performance. For this purpose, the reference vehicles were properly instrumented and tested under stationary lab tests as well as field tests. CNH was instrumental in formulating the test plan in collaboration with the Purdue team.

This project results demonstrate viable solutions that the future generation of agricultural equipment, including electrified tractors, can use to greatly reduce the energy consumption and therefore their environmental impact. This is in line with the societal needs for greener and more sustainable farming techniques.

### **Modeling and visualization tools for water management**

Purdue Research and Extension, along with North Central Region colleagues, collaborated to produce better soil spatial information and remote sensing data, and share it with end users via state-of-the-art visualization tools for sustainable agricultural systems management.

To improve hydrologic modeling, researchers used time-lapse photography and the DRAINMOD model to study surface ponding and runoff. They incorporated unmanned aerial vehicles (UAVs) and the RapidEye satellite to assess flooding impacts on crop yield. Using early season spectral data, researchers created algorithms to quantify soybean yield loss from excess water stress to improve the VIC-CropSyst model.

Researchers created a modeling framework for Drainage Water Recycling (DWR) to estimate irrigation and water quality benefits. Global sensitivity analysis showed that factors controlling total available water had the greatest influence on applied irrigation and captured tile drain flow.

Correlation analyses of water withdrawals and state groundwater doctrines, revealed that states following traditional “Eastern” water use doctrines had increased groundwater irrigation use, and increased water use during low surface water availability. This demonstrated that such doctrines are not designed to protect water resources during times of stress.

Researchers developed the Subirrigation Suitability Tool (SST). Agriculture lands suitable for subirrigation solutions likely have flat topography, a restrictive layer causing the water table to rise, and permeable soil above the restricting layer, allowing water to move horizontally between tile drains.

Four visualization tools were developed to identify and manage irrigation and water quality benefits.

- **Evaluating Drainage Water Recycling Decisions** (EDWRD) estimates potential irrigation and water quality benefits from DWR for multiple reservoir sizes. EDWRD integrates water balances for tile-drained fields and reservoirs to estimate how much water can be captured, stored, and reused. Irrigation benefits are quantified in relation to demand, while water quality benefits are quantified by percentage of tile drain flow captured by reservoirs.
- **Likely Extent of Agricultural Drainage** identifies agricultural areas likely drained with subsurface tile drainage for crop production.
- **State of Indiana Waters** provides real-time ground and surface water quantity and distribution data, including flood and drought monitoring.
- **Soil Explorer** visualizes soil properties in detailed, interactive maps via SoilExplorer.net and the Soil Explorer mobile app for iPhone/iPad and Android devices.

These efforts combine to provide relevant local information of land-use on water availability to meet the needs of farmers and crop consultants for water management strategies.

## Livestock

### **Meat processing solutions for premium beef and profitability of U.S. beef: Enhancing the competitiveness and value of U.S. beef**

Studies have reported consumer willingness to pay premiums for meat products with guaranteed eating quality, and consumers who shop in the local market generally have a high expectation of local meats. However, there is a need to better understand beef aging methods and post-harvest factors that ensure consumer demands are met.

The ultimate research goal was to establish novel meat aging processes that can be applied to improve quality attributes of cull cow beef and foster the profitability and sustainability of the beef industry.

Researchers determined impacts of post-harvest processing factors on meat quality attributes. Beef from cull cows has traditionally been perceived as low-quality/low-value meat due to inferior flavor and tenderness. Results indicated that conventional dry-aging would not negatively affect the shear force, cooking loss and oxidative stability of loins collected from mature beef loins. Trained panelists also indicated less sour and oxidized flavor in dry-aging compared to wet-aged counterparts, showing its potential to improve mature beef loins. These improvements, along with good color stability, suggested the potential of dry-aging as a natural value-adding process for merchandizing cull cow beef. UV light application significantly reduced microbial concentration of dry-aged beef crust, but an increase in oxidized flavor was found. Dry-aging treatments were observed to have greater amino acids and sulfur-containing compounds, while more lipid-related compounds were observed in wet-aged counterparts. This result potentially indicates the major mechanism of flavor production would be different depending on the aging method applied.

Knowledge generated by this project will have immediate implications to provide solutions to small/local meat processors, offer consumers more consistent premium meat products, and increase future profitability and sustainability of the U.S. meat industry.

### **Development of new tools to detect unlabeled food components**

To ensure food for safe consumption, rapid and accurate diagnostic tests are critical for the prompt recognition of pathogens. While detection of infectious agents has been a priority of food safety efforts, detection of unlabeled components of foods is also a growing concern; therefore, FDA/Vet-LIRN provided funding to create a meat speciation panel for detection of foods contaminated with various meat byproducts.

Researchers, developed and optimized materials and methods to rapidly and accurately detect a variety of animal species that may be present in meats. Primer pools were developed for a targeted next-generation sequencing panel to detect multiple mitochondrial genes: cow, bison, pig, sheep, chicken, turkey, canine, cat, mouse, rat – brown and black, macaque, salmon, cod, tuna, carp, tilapia, quail, pigeon, duck, deer, goat, buffalo, kangaroo, horse, and rabbit. A subset was selected for validation: cat, dog, rat, mouse, horse, cow and pig.

Analytical specificity was determined by spiking muscle tissue from these species in different combinations into a commercially available canned vegetarian dog food (matrix). Evaluation of targeted next-generation sequencing confirmed that primer sets were specific for intended species. Relative limit of detection (LOD-analytical sensitivity) was determined for the subset of targets by spiking the matrix with 1%, 0.1%, and 0.01% wt/wt muscle tissue from the different animal species. All seven species were detected at each concentration. Results for all seven species were found to be repeatable at all three concentrations.

A major output of this project is a testing methodology that allows for the rapid and accurate detection of food products that may contain meats other than those listed on the packaging labels.

### **Forage testing is critical for healthy cattle and cost-effective operations**

Forage quality is important to the supply of nutrients to cattle and other livestock. Recent extreme weather created weeks of delays in harvest. Delayed harvest contributes to poor feed quality for cattle. Routine testing of forage nutritional value is done by sending samples to chemical analyses labs, and working with nutritionists for developing feed rations to ensure nutrient requirements for cattle are met. Unfortunately, not all producers test harvested forages before winter-feeding begins.

Purdue Extension implemented several programs across Indiana to provide instruction on nutrition quality of forages and to encourage testing. Expanding reach, instructional materials and a video were created and shared across Extension and shown at Indiana Beef Cattle Association-Purdue University Regional meetings.

“Forage Analysis Testing Cost-Share”, with Soil and Water Conservation District and Natural Resources Conservation Service partners, provided free forage tests. Producers found testing to be a reasonable task and adjusted rations based on their specific results.

From Feldun-Purdue Agricultural Center's “Twilight Tour Field Day” producers better understood pasture renovation procedures, importance of harvest forage sampling and nutritional analysis before feeding, and supplementing stored forages.

After “Forage Quality and Testing Workshop” demonstrations, producers requested to borrow the county Extension office's hay probe and received bags so samples could be shipped to laboratories.

At the Southern Indiana Purdue Agricultural Center (SIPAC) “Grazing 102” workshop, wagon tours, hands-on demonstrations, and pasture walks, helped producers learn about soil fertility, forage-induced animal disorders, and animal nutrition. In the following six months, producers had adopted at least one recommended practice that increased returns or reduced cost per acre up to \$100.

Due to these programs, producers found visual demonstrations of poor-quality versus high-quality hay influential, encouraging them to match hay resources on the farm to nutrient needs of beef cows. “Considering the volume of hay an animal will need to eat to maintain balance, clearly, I have been giving my animals inadequate nutrients in the winter months all this time,” remarked a producer. Another said they knew hay analysis was a good thing, but didn't know it was such a big deal until this program.

Producers learned about poor quality forages resulting from extreme weather and late harvests, completed forage tests for quality, and worked with nutritionists to develop diets and rations that met nutrient requirements for cattle care and production, resulting in improved finances per acre for the enterprise.

## Horticulture and Natural Resources

### **Toward more productive, profitable, sustainable controlled-environment agriculture: Producing crops effectively and economically in controlled environments**

The global grassroots movement for local production of fresh, healthy produce is difficult to accomplish year-round in seasonal climates where there is a definite off-season for crop production. Without inputs of energy for heating, cooling, and lighting in protected horticulture, local off-season production of quality produce is not possible for year-round production in seasonal climates.

One controlled-environment crop-production project evaluated the capability of controlled-release fertilizer formulations in a soilless growth medium to provide plant nutrition for red-romaine lettuce cultivar 'Outredgeous' and Mizuna mustard for use on the International Space Station. Leaves were harvested at 28, 48, and 56 days after planting in six Biomass-Production Systems for Education (BPSe) plant-growth units with light-emitting diodes (LEDs) located in a temperature-and-humidity-controlled walk-in growth room. For lettuce, edible yield increased at each subsequent harvest for faster-releasing fertilizer formulations, but at the expense of leaf nitrogen content. Yields were lowest when using slowest-release fertilizer, but leachates from rhizospheres at the end of the experiment indicated nutrient-solution electro-conductivity (EC) was not limiting for any fertilizer treatment. Mizuna mustard responded differently from lettuce to controlled-release fertilizer proportions, decreasing in yield at each subsequent harvest, for both fertilizer formulations, but decreasing most with slowest-releasing formulation.

Another project involved growing a hydroponic crop stand (up to 48 plants) within a height-and-volume-adjustable cuvette space allowing CO<sub>2</sub> gas exchange to be monitored continuously throughout production cycles of leafy-green crops (e.g., 28-30 days). During that period, day/night temperature, CO<sub>2</sub> concentration, and several LED lighting parameters (adjustable intensity, spectrum, photoperiod) were controlled, and rootzone pH and EC monitored and adjusted. This "Minitron III" controlled-environment crop-growth/gas-exchange system was used to co-optimize different CO<sub>2</sub> and lighting conditions at different stages of the cropping cycle to promote rapid, efficient growth while minimizing energy inputs and resource utilization. Crop photosynthetic rate was being used as real-time response to current environmental growth conditions. The dimmable, selectively switchable lighting system self-monitors electrical-energy utilization, and after a crop-production cycle, crop yield and productivity parameters are measured and expressed as a function of energy cost for lighting.

This project developed controlled-environment agricultural technologies and methods to deliver adequate renewable energy for crop growth, development, and yield effectively and economically, so that crop production can be profitable for local producers throughout the year.

### **New tests for detecting bacteria on plant surfaces: Characterization of the lettuce microbial community by metagenomic sequencing and optical light scattering**

Although cases of foodborne illness attributed to consumption of fresh produce have increased dramatically in the past 20 years, there remain major gaps in our understanding of how well human pathogenic bacteria and fungi persist as plant-associated microbial communities and what factors influence their survival.

The overall goal of this research was to use next-generation sequencing, coupled with a light-scattering technology called BEAM, to identify bacteria and fungi present on romaine lettuce. This method will help establish a library for BEAM that can be used by the leafy green industry to rapidly sample products to determine the spoilage and/or pathogenic organisms present.

Three scatter image libraries were built to classify the nine most abundant bacterial genera isolated from romaine lettuce, which covered around three-fourths of the total culturable bacterial population. Results show the potential of BEAM technology to characterize culturable bacterial communities from environmental samples, and to study microbial interactions. However, specific challenges were identified, such as overlapping scatter patterns from strains of different bacterial genera, and the need to continuously feed the libraries with new scatter images of colonies isolated from new samples.

The research established baseline data for bacterial and fungal communities that are present on lettuce and how this influences the entry and persistence of human pathogenic bacteria on the plant surface.

### **Growing Together provides fresh produce for limited-resource Indiana residents**

U.S. and Indiana households are food insecure. An estimated 13% of Indiana residents were considered to be living in poverty in 2018. COVID-19 exacerbated economic and social situations, including food access for many families. Food insecurity is highly related to a number of health issues, such as iron deficiency, low bone marrow content, mental health, diabetes, obesity, and chronic disease in general.

Growing Together, a North Central Extension multistate effort including Indiana, Illinois, Iowa, Michigan, Nebraska, and Wisconsin, is a food access program to increase fresh fruit and vegetable availability to food pantries and other service agencies serving Supplemental Nutrition Assistance Program (SNAP)-eligible clients. During the 2020 growing season, Purdue Extension Master Gardeners (EMG), Purdue Extension Educators, and SNAP-Ed Nutrition Education Program Community Wellness Coordinators in 14 Indiana counties were engaged with community partners and 359 volunteers to create or expand 21 donation gardens to meet the needs of limited-resource individuals and families.

For Indiana, more than 3,000 volunteer hours (value of nearly \$75,000) were committed to planting, maintaining, harvesting, and supporting the 21 community gardens. Nearly 7,200 pounds of produce was grown and distributed to 33 organizations that served as distribution and education sites for more than 10,000 Indiana residents. Together, the Midwest states reached nearly 250 food pantries and distribution sites with more than 140,000 pounds of donated produce, serving 99,540 low-income individuals.

As a result of Growing Together, thousands of limited-resource Indiana residents had access to fresh fruit and vegetables.

### **North Central Climate Collaborative (NC3): Action to address climate change for farm, operation, family, or community**

Climate dictates what crops grow where, how water resources are distributed, and how storm water infrastructure is built. Climate change threatens communities and farms accustomed to a certain amount of annual precipitation, sunny days, or winter snowpack. Extension is positioned to educate about climate change adjustments, but many Extension personnel lack the education to teach it, resulting in very little available programming.

The North Central Climate Collaborative (NC3) strives to increase the flow and usability of climate information for Extension, farmers, natural resource managers, communities, families, and youth. Webinars were started to build climate change training with more than 1,000 participants and 680 website or YouTube views.

The North Central Climate website was created to house educational content for anyone wanting to learn about climate issues and now averages more than 200 views monthly. Webinar participants reported learning something new, and two-thirds reported an interest in sharing the information. Participants increased knowledge, skills or attitudes about sustainable agriculture topics, practices, and strategies, and agriculture professionals intended to use the knowledge they gained.

Extension, Purdue Climate Change Research Center, and the Indiana State Climate Office conducted a needs assessment of Extension personnel and found interest in understanding the science behind climate change, tips for finding and interpreting trusted climate data, Indiana climate change trends, and best practices for effective communication and dealing with science skeptics. One-third were not comfortable presenting climate-related material. So, a six-webinar series was implemented and had nearly 1,000 attendees, and more than 700 accessed the recordings.

Two professional development trainings were provided for Extension professionals and partners. Nearly all reported after the training that they were more comfortable providing climate change programs. A majority reported intending to offer more programs and to recommend changes to agricultural operations. Two-thirds felt the series increased their confidence to discuss climate change. A participant wrote, "Framing discussion is so important in talking confidently, and making the discussion relate to the audience seems effect[ive]". Another said, "I find it hard to know how to correctly approach someone who may have a different opinion, especially on a topic that is so polarizing. I appreciated the techniques and advice on how to talk to others about tough topics."

Collaboratively building climate change resources and making them available to Extension professionals, partnering agencies, and the public has been a successful approach to ramping up what people know about climate change. Via professional development, Extension professionals and partners gained knowledge and confidence to share

information and programs with the public. And public participants gained knowledge, confidence to discuss, and intended to act regarding climate change for their farm, operation, family, or community.

### **Managing emerald ash borer in urban and natural forests: Minimizing impact on the environment**

Emerald ash borer (EAB) is an invasive woodboring beetle that threatens to destroy ash trees in North America. Recent research suggested ash tree mortality can be slowed by treating just 40% of trees in a community with insecticides and targeting the period before first eggs of EAB females. Called Slowed Ash Mortality (SLAM), this approach is based on applying insecticides early in the invasion to kill most beetles before eggs are laid. Most municipalities, however, are hesitant to employ this tactic without validation of varying stages of EAB invasion.

The research goal was to assess an evidence-based strategy for protecting ash trees from EAB by judiciously using insecticides to prevent growth in beetle populations and slow ash tree mortality.

While the SLAM program reduced overall mortality of untreated ash trees, survivorship varied considerably between sites. In the first site, SLAM was most successful (54% ash survival) where initially < 10% of ash trees were moribund (canopy thinning > 30%) and 40% of all ash trees were treated with the insecticide emamectin benzoate every two years. SLAM was less successful (38% survival) in a second site where 15% of trees were treated with emamectin benzoate and 25% with annual applications of another insecticide, imidacloprid. In the third site, where 51% of an ash forest were initially moribund and 40% were treated, only 23% survived.

Overall survival of treated ash trees declined by 18-22% and trees that were not moribund were most likely to survive. Although many treated trees, initially moribund, regained their health, this was not the case for untreated ash trees. SLAM was most successful for untreated and treated white ash, which were more likely to survive than green ash trees. Untreated ash trees at all three sites were more likely to survive when closer to trees treated with emamectin benzoate, but not to those treated with imidacloprid. Findings suggest SLAM can protect urban ash trees, but success is strongly influenced by initial tree condition, species composition and proximity to treated ash trees.

This project provides evidence for an area-wide strategy to suppress EAB that could substantially reduce the costs of managing ash trees in cities, and retain the benefits provided by mature urban trees, with minimal impacts on non-target organisms or the environment.

### **Engaging family forest owner: Key to reducing invasive plant spread into forest ecosystems**

Most U.S. forest invasive plants were introduced through horticultural landscaping or conservation. Because of limited evidence documenting Family Forest Owners' (FFOs) perceptions of invasive plants and associated forest ecosystem impacts, researchers assessed knowledge, attitudes, beliefs and behaviors of FFOs in the North Central Region. The purpose was to evaluate barriers to reducing invasive plants and to identify opportunities for promoting individual and collective management actions.

Results showed that FFOs had moderate familiarity with, concern about, and interest in invasive plant control on and around their forest properties. Despite reporting lack of confidence in their ability to manage invasive plants, many FFOs had taken actions on the ground, including inspecting their woodlands and removing invasive plants, all without much input from natural resource professionals. Some FFOs had also talked to their families and other landowners about invasive plants. Most FFOs relied on self-directed learning and social networks for invasive plant-related information and advice. They had little or no experience, or interest in, interacting with natural resource professionals.

FFOs had greater intentions to manage invasive plants individually on their own properties when they perceived the problem to be more severe, when they had previous invasive plant management experience, or when they felt a stronger sense of self-efficacy to address the problem. Importantly, FFOs who were more subject to normative social influence were more likely to engage in individual invasive plant management activities. FFOs who had bachelor's degrees or higher levels of education, or owned woodlands for recreational purposes, also tended to have greater intentions to manage invasive plants. In terms of collaboration and cooperation, previous experience of talking to others or working with neighbors to remove invasive plants were important predictors of landowner intentions to work collectively. Perceived need for collective management and concerns about invasive plants on neighboring or nearby properties were also important predictors of landowner intentions to work collectively. Finally, and importantly, perceiving self-efficacy and being subject to normative social influence were not only important predictors of landowner intentions to manage invasive plants individually, but collectively.

For natural resource professionals, these results suggest a need to focus on developing partnerships with non-profit organizations trusted by FFOs to encourage self-organization and sharing of information and resources, stronger online presence to facilitate self-directed learning, and communication strategies to target specific segments of FFOs. Perceived severity and self-efficacy may be used to inform potential strategies, programs, and outreach for engaging FFOs in invasive plant management. Building individual competence and shared concern, and more importantly, developing nonintrusive and creative ways to amplify social norms associated with invasive plant management, may facilitate community-led collective action to manage invasive plants.

This research produced new insight on FFO knowledge, attitudes, beliefs, and behaviors with respect to the management of invasive plants and shed light on future opportunities to reduce the spread of invasive plants into forest ecosystems.

## Food, Nutrition, Families and Health

### Facing mental health and building support in the community

Mental health and substance use issues are widespread but are perceived differently from physical health. This perpetuates shame, discouraging individuals from seeking or accepting help. Youth are impacted, as half of all chronic mental health conditions develop by age 14. Farming is chronically plagued with stressors of weather, regulations, input costs, and market prices. Increasing financial strain results in chronic stress, anxiety, and depression for farm families, threatening the livelihood and heritage of family farms. The COVID-19 pandemic compounded mental health issues.

Purdue Extension delivered “Youth Mental Health First Aid”, an eight-hour course for adults interested in learning about youth mental health issues. The course covers signs and symptoms of mental health and substance use issues, and tools for first-aid level assistance to adolescents experiencing crises. Adults learn how to be a resource and provide support to youth at risk. As a result, about 200 adults were confident they could reach out to youth having mental health problems, substance-use challenges or crises, in recognizing signs of mental health problems, and in asking adolescents whether they are considering killing themselves. Adults indicated, “It is a course that is needed in all schools,” “Definitely useful training that will help me in my volunteer role,” and “Good info for first responders.”

“Weathering the Storm in Agriculture” for farmers and families, and “Communicating with Farmers Under Stress” for those in the community who interact with farmers, address signs and symptoms of chronic stress, where to go for more help and resources, recognizing and responding to mental health concerns, and techniques for identifying, approaching and working with stressed farmers.

Over 1,550 farm stress participants across Indiana reported increased understanding of the impact of stress on the body, confidence identifying signs and symptoms of stress in someone, knowledge of where to send someone for help, confidence communicating with someone experiencing stress, understanding of suicide warning signs, and knowledge of current agricultural financial situations.

Participants learned the physical impact of stress; as expressed by one participant, “All of the different ways (not just mental) that stress can affect our bodies.” Participants shared the coping and communication skills they learned: “I learned a good breathing technique that helps release tension and reduce stress.” “The suicide information was valuable, because just something not in my vocabulary, so I had no clue how to have that conversation.” “How to talk to someone and be positive and be empathetic.” “How to approach a stressed farmer and a high-stress situation on a farm setting.”

Results affirm the value of training adults who care for and support the mental health of Indiana’s youth, and farmers, their families, and those in agriculture-related businesses/organizations, and other professionals. Better understanding of physical impacts of stress, tips to manage stress, how to recognize signs of stress, and how to talk with those in distress helps build support for youth and adults across Indiana.

### Exposure to the herbicide atrazine and influence on mental health pathways

Atrazine (ATZ), the second most commonly used agricultural herbicide in the U.S., has been linked to a variety of detrimental health effects. Importantly, the central nervous system has been identified as a potential target of ATZ; however, impacts of ATZ on neurological development are still largely unknown.



Zebrafish were used as a model to evaluate the impact of ATZ exposure on the developing neurological system. Fish were exposed to ATZ during embryogenesis and allowed to mature under control conditions until adults. Neurobehavior assessments were completed as well as an analysis of gene expression changes in the brain of male and female zebrafish.

Male zebrafish exhibited decreased locomotor parameters during behavior tests at nine months post fertilization. Analysis of RNA molecules revealed a number of pathways and networks were altered, including those involved in organismal development, cancer and nervous and reproductive system development. Microscopic examinations of brain tissue led to a discovery of decreased number of cells in raphe populations (serotonin-producing cells in the midline of the brainstem).

In addition, assessments were completed in human cell systems to define mechanisms of ATZ neurotoxicity. Human cells exposed to ATZ exhibited numerous gene expression changes, including decreased methylation of histones, presumably resulting in gene silencing.

The research demonstrated that developmental exposure to ATZ affects neurodevelopment and neural function in adult male zebrafish, establishing the need for additional studies to evaluate the significance of ATZ-induced brain dysfunction.

### **Identifying bioactive food compounds and the molecular mechanisms controlling adipose development and obesity**

Obesity is associated not only with increased adipose mass but also with an aberrant activation of hydrolysis of fats accumulated in adipose tissue, termed lipolysis, a risk factor for the development of obesity-related diseases. Thus, moderate inhibition of lipolysis has been proposed to be an effective approach to delay the development of both obesity and its related metabolic disorders.

The long-term goal is to identify and characterize novel dietary factors that modulate adipose tissue development and function, to provide dietary strategies for obesity prevention and related chronic metabolic and inflammatory diseases. Our objectives focused on explaining the molecular mechanisms underlying anti-obesity function of bioactive components and the metabolic impact linking adipose tissue and other pathogenic tissues, such as cancer cells, using both cultured cell systems, invertebrate animals, and animal models of obesity and/or cancer.

Piceatannol, a natural analog of resveratrol found in fruits and red wine, is suggested to promote health. Researchers identified that piceatannol inhibits lipid droplet (LD) synthesis and fat cell development by suppressing insulin-related signaling pathways. Piceatannol also suppresses obesity-associated lipolysis, resulting in lowering release of free fatty acids from adipose tissue in cultured fat cells and obese mice. These findings firmly place piceatannol as a novel anti-obesity compound that could regulate generation of LDs and development of obesity, and obesity-induced aberrant free fatty acid release. Overly activated adipose lipolysis is recognized to be primarily responsible for cancer-associated muscle and fat wasting. Since piceatannol is shown to inhibit adipose lipolysis effectively, in collaboration with Purdue University Center for Cancer Research, our group demonstrated piceatannol protects animals from cancer cachexia-induced adipose lipolysis. This finding allows researchers to develop an innovative strategy to treat cachexia-associated adipose tissue loss during cancer therapy.

These studies are significant because the results provide new insights into therapeutic approaches to uncouple obesity and its-related metabolic diseases, and cancer-induced wasting.

### **The influence of cereal bran and bran arabinoxylan chemical and physical structure on the human gut microbiome**

Low gut microbiota diversity is associated with multiple diseases, including chronic metabolic diseases, such as metabolic syndrome and type II diabetes. Recently, it has been determined that loss of species from the gut microbiome is linked to consumption of the high-fat, low-fiber Western diet, which starves colonic microbiota of the dietary fibers they ferment as their primary energy source. Therefore, understanding how the physical structures of carbohydrates influence the gut microbiome will allow for targeted dietary interventions to repopulate very low-abundance gut microbiota.

This research sought to address relationships between chemical structural properties of soluble and insoluble bran fibers, gut microbial ecology, fiber metabolic fate, and host physiology; and the degree to which physical properties of insoluble fiber carbohydrates impact structure and function of gut microbial communities.

Researchers determined that bran particle size influences are not limited to wheat, but more broadly influence interactions of cereals with the gut microbiome. Fine structures in bran arabinoxylan (found in cell walls) select for different microbial communities.

For whole particles, maize bran exhibited a similar size-dependent fermentation as for wheat brans, with similar shifts in short-chain fatty acid production. Furthermore, specific microbes were associated with maize bran particles differing in size, although this effect was not as strong as observed in wheat, owing to their slower overall fermentability. These experiments demonstrated that particle size effects are likely common across cereal bran fibers. For soluble bran fibers, small variations in fiber structure make significant impacts on which microbiota are most successful in fermenting them and the metabolic outcomes of fermentation.

Research findings established foundational understanding of how cereal brans and their composite arabinoxylans influence gut microbiome diversity and function *in vitro*, providing a foundation for future *in vivo* studies of interfaces between cereal bran fibers and microbiota to improve gut health.

### **Indiana adults take control of their personal finances**

Due to the COVID-19 pandemic economy shutdown, personal savings rates increased from 7.5% to 33.5%, a single, positive trend. Yet in 2018, American households spent 65% of their income for housing and health care. In 2017, U.S. workers (78%) were living paycheck to paycheck. Nearly 75% of workers were in debt.

Purdue Extension presented “Where Does Your Money Go?”, virtually or in person, to 260 adults across 28 counties. Modules were also available through Facebook Live and recorded videos. This financial program, delivered via two instructional sessions, covers how small purchases add up to large expenses over time and determining “needs” versus “wants.” Adults discover their spending leaks (repeatedly spending money in certain areas without thought) and identify financial priorities. They also develop skills to make spending plans (a budget) tailored to financial needs and to achieve personal goals.

On post-surveys, participants reported increases in intended behavior change of personal financial management. Nearly all reported they could have more money if they made different spending choices. A majority reported they are thinking differently about how they manage their money. Median amount for spending leaks was over \$4,000, and adults indicated that money could be used to start saving or pay off bills. Participants stated that this program “made me realize things like the fact that making coffee at home is a lot cheaper than purchasing a cup of coffee out every day,” and resolved to “absolutely no more pay-day loans and rent-to-own items.”

After session two, participants had written a financial goal, found bills easier to pay because of new spending choices, saved money since the first session, and decreased debt. Three months later, adults had reduced their spending leaks, were managing their money better, and had developed a spending/savings plan. One stated, “I realized how much we were spending/wasting on eating out. We now limit to once a month and save at least \$200/month.” Indiana adults and their families are benefiting from the financial skills acquired to help them spend and save money more effectively.

### **Get WalkIN' participants increase their physical activity for health**

Americans are not meeting physical activity guidelines. Physical inactivity is directly related to prevalence of obesity in adults and youth. In Indiana nearly three-fourths of adults are considered overweight or obese and almost half self-report not meeting physical activity guidelines.

Walking is an easy way to start and maintain a physically active lifestyle. Walking is accessible to almost anyone, does not require specific skills or abilities to perform, can be performed alone or with others, is adaptable (i.e., can be performed at any chosen intensity), and is inexpensive.

Purdue Extension provides physical activity education for adults and ways to increase walking behaviors with Get WalkIN', a 12-week series via e-mails sent twice weekly for weeks 1-4 and once a week for the last eight. Topics are benefits of exercise, how to overcome barriers, principles of self-efficacy, social support, goal setting, walking locations, and relapse prevention. Educators help motivate participants to make simple changes to their daily routine to improve physical activity, health and well-being. Get WalkIN' reached nearly 700 individuals.

At the start, participants were walking an average of 146.2 minutes per week, and this increased to 310.3 minutes at the end. Just 28% met national physical activity guidelines at first, but this increased to 92% at the end. During the

program, participants reported an average of 297.0 minutes of walking per week, and three-fourths reported meeting physical activity guidelines.

Self-efficacy (believing in ability to succeed) and social support from friends and family increased from program beginning to end. Participants reported receipt of emails encouraged them to increase their walking. Participants reported being highly likely to continue to use information they learned.

As a result of Get WalkIN', participating adults increased their walking and overall physical activity behavior, which are positive factors for their health and weight.

## Youth Development

### Youth design technology to solve real-world issues

Data on 15-year-old student math literacy show 21 countries with higher average scores than the U.S. According to the National Inventors Hall of Fame, science, technology, engineering and mathematics (STEM) education emphasizes preparing future generations for success.

Indiana 4-H Computer Science was supported by a National 4-H Council and Google partnership for opportunities for rural and underserved populations. Google provided curricula and tools for 4-H to train youth and adult volunteers. Staff from the five funded states – Indiana, California, Illinois, New York and West Virginia – gathered monthly to collaborate on initiatives, events and training.

For Indiana, an in-person, on-campus computer science event on STEM and agriculture, civic engagement, and healthy living, was in the works when coronavirus restrictions closed schools. Quickly changing gears, the World Changers 4-H Online Hackathon was created. Emails to principals and posts on National Computer Science teacher Facebook groups promoted the event to 4-H members and all youth ages 12 to 18. Youth were encouraged to propose a real-world solution using coding and other technology. Youth selected a problem to address: finding quality mental health services for adolescents, helping service organizations identify food deserts or creating a service project to help solve food insecurity locally, using digital tools to identify insects/weeds/diseases in fields or forests, or helping producers in grain sales and trucking identify and calculate elevator cash bids to determine highest return.

Extension provided instruction videos, FAQs and links to resources. Youth created a mockup, decided the coding language(s), learned needed skills, and tested their project. Final project items created were a short video, screencast of the working product, audio walk-through and reasons for the project, the code and app. Youth produced a video in which they discussed the selected problem and how it could be solved. Youth were encouraged to seek out a mentor, family member, friend, teacher, or club leader to provide guidance to them. Projects were judged on technical aspects and presentation skills describing the problem and why they selected it.

In this first year, 85 youth and seven mentors participated. The grand prize winner created an Indiana county mental health resource for youth. The reserve grand prize winner created an app defining a food desert and helping users find places to volunteer. This online event launched virtual computer science activities for the rest of the pandemic year, reaching 3,278 youth with help from 303 volunteers via nearly 300 hours of instruction.

As a result of this hackathon, Indiana youth had opportunities during the pandemic to learn and apply STEM skills.

### Soccer & 4-H @ Home keeps youth active

CDC data on the health status of youth show 21% of adolescents and 18% of children are obese. Only 1 in 5 high school students meet the recommended physical activity guidelines.

To encourage physical activity in youth, as part of Soccer for Success, a collaboration between 4-H and the U.S. Soccer Foundation, and at the invitation of RightFit, an Indianapolis afterschool program, Purdue Extension implemented a research-based curriculum integrating soccer play with nutrition and youth development through mentoring. RightFit, funded by the Indianapolis Indians Foundation, provided funding and school sites, and Metropolitan Soccer supplied 44 college-age coach mentors. These partnerships gave Purdue Extension the opportunity to connect with underserved youth and new audiences in urban areas.

Due to COVID-19, the 13-week program, with just a few weeks delivered in-person, had to be adapted to a virtual experience. "Soccer & 4-H @ Home" in Spanish and English, for grades 3-10, was created as a summer program for

500 Indianapolis youth who had started the program prior to pandemic restrictions. This “at your own pace” program was shared with youth in Florida and Missouri, too. Weekly engagement activities and videos focused on soccer fundamentals, learn and earn, home challenges, do and serve others, and eat well.

A few activities were “picture your food,” which highlighted where food comes from, soccer fun-fact videos illustrating history and relevance worldwide, actions to be physically and mentally healthy, and exploration of sports-related careers in business, medicine, engineering, agriculture, education, and communication. Youth completed weekly reports on their engagement, use of program resources, and knowledge gained.

Indiana, Florida and Missouri 4-H programs reported over 4,000 active online users from May to July. More than 600 completed at least one weekly report. Youth reported they had learned facts related to soccer sports history, food production and agriculture, new opportunities available in the 4-H program, how to prepare new healthy recipes, careers related to the sports industry, and techniques that promote well-being.

Soccer & 4-H @ Home was selected to be available on the National 4-H Council site and is the only bilingual program. Participating youth benefited from this program that kept them physically active and helped them learn healthy eating and cooking skills during pandemic social restrictions.

### **Indiana 4-H teens grow in leadership**

Positive youth development requires growth opportunities for personal mindset, social skills, and emotional, character and leadership skills. Essential elements are positive relationships with caring adults, inclusive and safe environments, engagement in learning, and opportunities to see oneself as an active participant in the future and to value and practice service for others.

Growth opportunities were provided for 86 Indiana high schoolers attending the 4-H Junior Leader Conference. The 16-member Junior Leader Council worked with Extension to plan and implement activities. From the “Leadership and Laughter” keynote, youth learned techniques to overcome challenging situations, stay connected virtually or in-person, and build leadership. Council member pairs led skill sessions about teambuilding, understanding different cultures, and healthy lifestyles. Business and industry professionals shared tips about educational and professional development for workplace success. Youth completed a service project using old T-shirts to create dog toys. Attendees shared this prototype with youth in their communities to generate donations for local animal shelters.

As a result, youth learned about maximizing their 4-H experience, stating, “One thing I learned is how to use my 4-H experience to its fullest potential to serve my community,” and “I learned how being in 4-H can help you grow into the career you want in the future.” Youth learned better work habits to plan and prepare for their future.

Youth connected with others, stating, “One thing I learned is how to communicate with people you don’t know that well!” Another reported, “I learned how to get people engaged. I will be using the icebreakers that I learned about with my campers next summer!”

Youth wrote thanks to event sponsors and organizers, stating, “Thank you for giving me this opportunity to learn and grow. This conference gave me a lot of information and tips that I will be able to use in my life.” Another indicated, “I would like to sincerely thank all the sponsors for this wonderful and educational experience and talking to us about your careers in agriculture.”

Youth appreciated the virtual event, saying, “This was a wonderful experience. It was nice to still be part of 4-H and Jr. Leaders even though it was not in person. Thank you for making sure this happened. It was nice to learn and have fun.”

### **Food safety training for high school**

By hosting focus groups with over 50 science and agriculture high school teachers, Purdue researchers identified academic needs for food safety education, including lack of curricula aligned with state standards, lack of student interest in food safety, and lack of instruction time and resources. In response, a comprehensive extension program called “Food Safety in The Classroom” was created. The curriculum provided students with fundamental food safety concepts through experiential learning and incorporated science, technology, engineering, agriculture, and mathematics (STEAM) activities in the context of careers related to agriculture, especially in food science. The new curriculum aligned with Indiana Academic Standards for Agriculture, Advanced Life Science for Foods.

A panel of experts in education evaluated the curriculum through three rounds of surveys containing questions related to six curriculum assessment topics. Experts rated their agreement with statements about the curriculum using 5-point scale and multiple-choice questions. All experts agreed the curriculum addressed academic standards and was engaging for students, and most agreed it was easy for teachers to use. They noted the curriculum successfully incorporated STEAM (100.0%), experiential learning (89.5%), and career-education (78.9%). Over half of the experts identified the only barrier to curriculum incorporation was the cost to purchase materials for cooking labs.

An observational evaluation of the curricula on students' food safety and handling skills included a combination of stationary and wearable (GoPro) cameras to observe food handling practices of high school students in food thermometer use, hand washing and drying, glove changing, and environmental cleaning. The percentage of students using correct hand washing, hand drying, and glove changing techniques significantly increased in the post-observation cooking session. However, percentages of students with correct hand washing and glove changing events remained below half for changing gloves after gloves became contaminated or torn (47%), hand washing time (38%), hand washing after handling raw produce (36%) and touching skin (20%), and washing hands between glove changes (15%).

This new curriculum increased food safety behaviors which can impact the health and wellbeing of our communities (e.g., homes, fast food, restaurants) while providing STEAM-incorporated educational content into high school classrooms.

## Community and Business Development

### On local government: COVID-19 Response

In early 2020, local governments in Indiana quickly responded to COVID-19, closing buildings, providing services in modified/virtual ways, communicating with communities about the crisis, and forecasting how revenues would be impacted. Practically overnight, government officials needed a whole new skill set to serve their communities. Adding to the challenge, social distancing made local officials more isolated, restricting their ability to collaborate with other units/agencies to resolve challenges raised.

During the pandemic, Purdue Extension provided a central location for local governments as they worked to keep their constituents healthy, safe and well informed. Extension collaborated with Indiana local government associations to provide a website for webinars and resources, reaching nearly 1,300 local government officials and community leaders via webinars about the economic outlook, State Board of Account (SBOA) and Department of Local Government Finance updates, crisis communication, programming with online platforms, and navigating grant opportunities.

Extension hosted virtual, weekly COVID-19 roundtables where networking created opportunities for local government leaders to share information, questions, and ideas about COVID-19 impacts and responses. Meetings focused on the "Indiana Back on Track" plan, challenges, helpful tips, what to do differently, current county needs, and next big steps. Each week Extension facilitated these discussions between library, township, municipal, and county leaders. In some, elected state representatives shared pandemic impacts on local units to help participants generate ideas about how to address community issues. Participants gained insight that helped them address the pandemic.

Extension forged new relationships, providing advice for virtual Q&A sessions and budget workshops. Over 60 participants increased their knowledge on where to get personal protective equipment (PPE) when resources were scarce and shared methods to help reduce pandemic spread in public buildings and services.

In northwest Indiana, a group of participants wanted to continue conversations and collaborated with Extension to restructure, resulting in a new leadership development forum for the region, eliminating duplicative activities for post-pandemic transition. In eastern Indiana, Extension partnered with Blackford County Economic Development to gather information from business owners about COVID-19 impacts and found financial difficulties, including shutdowns, employee furloughs, and temporary closings. From local official assessments identifying needs for PPE funding and other COVID-related expenses, grant applications were submitted to the Indiana Office of Community and Rural Affairs (OCRA) for COVID-19 Relief Funds. OCRA awarded over \$426,000 for PPE, COVID-19 testing, for the local food pantry, and to the community for job retention to assist hardest-hit manufacturers and closed businesses.

Purdue Extension provided opportunities for local governments to learn and connect during the pandemic. These efforts helped communities and businesses with information, collaboration and funding during challenging times and economic hardships.

### **Navigating difference and cultural awareness workshops build cultural competence for Hoosiers**

In recent decades, Indiana has become increasingly more diverse across ethnicity, race, religion and other human differences. Many organizations who serve Hoosiers broadly see a need to build cultural competence to increase their ability to fulfill their mission and to improve the climate of their workplaces.

Navigating Difference is a cultural competency training developed by Washington State University. Purdue Extension provides the program across Indiana for those who want to deepen their knowledge, skills and appreciation for connecting across diversity with clientele, coworkers and community members. Its five modules include elements from social justice, intercultural communication and organizational development. Purdue Extension also offers a half-day interactive workshop on the first module, cultural awareness.

When Indianapolis Public Library System's (IPLS) director of human resources attended Navigating Difference, she knew it would help IPLS improve outreach and service to underserved and vulnerable populations, homeless patrons, new immigrants and refugees, low-income families and individuals, and people with disabilities, including mental illnesses. Over three years, all 108 IPLS managers and supervisors completed the three-day intensive training, and the remaining over 500 staff built cultural awareness skills in a half-day workshop. Other groups across Indiana completing the half-day training last year were community leadership programs in seven counties, Retired Senior Volunteer Program (RSVP) and South Bend Community Schools staff.

On post-surveys after the three-day training, most participants improved their recognition of how power, privilege, and oppression may affect their work with people from cultures other than theirs, how motivated they feel to act to build their cultural competence, how confident they feel to take steps to navigate cultural difference effectively, and their understanding of the barriers to intercultural communication.

### **Green infrastructure in the North Central Extension Region: Building an equitable and just strategy and workforce**

Communities are adopting green infrastructure (GI) practices as low-cost ways to update aging stormwater infrastructures. To residents, GI looks like parks, gardens, parking lots, and green roofs, and can provide important community amenities, such as recreational spaces and pollinator habitat. Though communities face similar challenges, practices used to address them vary considerably. This is particularly true for the co-benefits of GI, such as recreation and beautification, where best practices are not well defined. Distribution of GI throughout a community has a major impact on who benefits. When GI is sited in disadvantaged communities, its impact on local property values may lead to displacement of longtime residents. While experts project the jobs in the GI industry will grow, communities struggle to provide sustainable careers within GI and build a workforce that more closely matches population demographics and is accessible to more people.

Purdue Extension, Illinois-Indiana Sea Grant, and other colleagues are leading a project to identify the intersection of social justice, workforce development, and GI programs as growth opportunities in the 12-state North Central Region.

Funded by the North Central Regional Water Network, the team conducted 18 listening sessions in over 30 communities across nine states. The team coordinated a virtual Equitable GI Summit with over 100 participants from Extension, Sea Grant, state and local government agencies, nonprofits, and private businesses to synthesize listening sessions and prioritize barriers and opportunities.

Several GI recommendations were identified. First, keep projects simple to lower installation costs and reduce the burden of care over the project lifetime. Second, emphasize co-benefits. Communities with multiple societal benefits were more successful implementing low-cost GI networks. Third, design GI careers rather than jobs, as careers have opportunities for advancement. Fourth, provide education at every level for government staff, officials, and city planners to implement GI policies, contractors and crews for performance and maintenance, decision-makers for function and value, and K-12 students as the next generation of sustainers. Finally, build relationships and establish partnerships for sharing knowledge and resources and expanding opportunities.

Findings showed societal aspects for designing GI resulted in greater community and internal support, greater ability to secure additional funding through grant programs, and greater integration between GI and other community-benefit programs. Explicitly including co-benefits and economic costs and benefits in the decision-making process helped communities address multiple needs, thus deriving more value from money already committed to stormwater or other capital improvements.

Communities now have a guide for building an equitable and just Green Infrastructure strategy and workforce: <https://northcentralwater.org/files/2020/09/EquitableGreenInfrastructure-9-24-2020.pdf?x16165>

### **Community development: Turtle Mountain Reservation's substance use disorder recovery center**

In partnership with the Purdue Center for Regional Development and the University of Kentucky, Purdue Extension secured a USDA Rural Economic Development Innovation (REDI) grant to foster rural development in nine communities in the North Central and Southern regions. For one of the nine, the Turtle Mountain Band of the Chippewa in North Dakota, their dream was to create a substance use disorder recovery center.

Purdue generated a data snapshot of Turtle Mountain Reservation that showcased Quality of Life, Workforce Development, Economic Development, e-Connectivity and Technological Innovation as critical elements for the region. A two-day workshop shared information and tools for developing goals, objectives, strategies and a timetable. Monthly writing team calls, bimonthly REDI support calls, quarterly USDA Rural Development webinars, and many virtual meetings with the local team were coordinated and conducted.

Purdue Extension, the School of Nursing, and the Turtle Mountain team created a clinical plan outlining detailed service, staffing and building design needs, and a business plan incorporating a demand and supply analysis, staffing cost projections, revenue projections with information on workforce development needs, billing requirements, and USDA community facilities loan details.

Extension brought in the Purdue Center for Community and Environmental Design for consultation to generate an outdoor site plan to enhance the natural environment and provide patients and families opportunities to interact with the land. A draft plan, detailed site designs, and computer visualizations were presented to tribal leaders and staff, whose enthusiastic response led to more comprehensive designs, including a welcoming garden experience, therapeutic gardens and learning spaces, and separate spaces for reflection and solitude. Primary roadways and patient housing are already under construction, as the tribe finalizes funding for remaining facilities.

Ongoing work will further develop the recovery-oriented system of care, and create funding strategies and promote organizational and workforce development. The tribe will coordinate installation with local design, engineering, and construction firms. At completion, the 100-acre campus will integrate a new central facility, recovery residences, confidence course, equine therapy stables, sweat lodge, medicinal garden, and walking trails for the Turtle Mountain Band of Chippewa Indians community.

## Collaborators

### Agriculture

#### Farm Management

##### Management advances and increased revenue for Midwest women in agriculture

*Contact:*

Kelly Heckaman, Interim East District Director, County Extension Director, Kosciusko County,  
[kheckaman@purdue.edu](mailto:kheckaman@purdue.edu)

*Collaborators:*

Jenna Nees, Agriculture & Natural Resources Educator, Putnam County  
Nicole Witkowski, Agriculture & Natural Resources Educator, Porter County  
Danielle Walker, Agriculture & Natural Resources Educator, Washington County  
Ophelia Davis, Agriculture & Natural Resources Educator, Lawrence County  
Elysia Rodgers, County Extension Director, Agriculture & Natural Resources Educator, DeKalb County  
Denise Schroeder, Health & Human Sciences Educator, White County  
Beth Vansickle, Agriculture & Natural Resources Educator, Madison County  
Annetta Jones, County Extension Director, Health & Human Sciences Educator, Porter County  
Abigail Creigh, Health & Human Sciences Educator, Noble County  
Marguerite Bolt, Hemp Production Specialist  
Angela Sorg, Health & Human Sciences Educator, DeKalb County  
Mark Carter, Agriculture & Natural Resources Educator, Blackford County  
Krishna Nemali, Assistant Professor, Controlled Environment Agriculture  
Edward Farris, County Extension Director, Agriculture & Natural Resources Educator, Huntington County  
Krista Pullen, Agriculture & Natural Resources Educator, Community Development Educator, Cass County  
Marisa Erasmus, Assistant Professor of Animal Sciences  
Keith Johnson, Professor of Agronomy  
Tanya Hall, Regional Community Development Educator, Southeast District  
Patricia Keating, Community Development Educator, Porter County  
Laurynn Thieme, Agriculture & Natural Resources Educator, Delaware County

##### On-Farm readiness reviews and mock audits keep Indiana producers in business

*Contact:*

Scott Monroe, Food Safety Extension Educator, [jmonroe@purdue.edu](mailto:jmonroe@purdue.edu)  
Amanda Deering, Clinical Associate Professor of Food Science, [adeering@purdue.edu](mailto:adeering@purdue.edu)

*Collaborators:*

Tari Gary, Indiana State Department of Agriculture, Indiana Department of Health

*Source:*

[www.safeproducein.com](http://www.safeproducein.com)



## Crops

### **Sorghum gene discovery and trait development for livestock feed: Gene discovery and functional validation in sorghum**

*Contact:*

Mitch Tuinstra, Professor of Plant Breeding and Genetics, [drmitch@purdue.edu](mailto:drmitch@purdue.edu)

### **Advancing the sustainability of weed management across the landscape: Controlling weeds for natural resources and agricultural systems**

*Contact:*

Bryan Young, Professor of Weed Science, [BryanYoung@purdue.edu](mailto:BryanYoung@purdue.edu)

*Collaborators:*

Bill Johnson, Professor of Botany and Plant Pathology

Kevin Gibson, Professor of Botany and Plant Pathology

Stephen Meyers, Assistant Professor, Weed Science

### **Corn, soybean and environmental responses to integrated 'cropping systems' that are potentially more stress-resilient**

*Contact:*

Tony Vyn, Henry A. Wallace Chair in Crop Sciences, Professor of Agronomy, [tvyn@purdue.edu](mailto:tvyn@purdue.edu)

## Digital Ag

### **Machine systems and automation for increasing productivity and efficiency of crop production**

*Contact:*

John Evans, Assistant Professor, Agricultural & Biological Engineering, [jevansiv@purdue.edu](mailto:jevansiv@purdue.edu)

*Collaborators:*

John Lumkes, Professor, Agricultural & Biological Engineering

Greg Shaver, Professor, Mechanical Engineering

Ankita Raturi, Assistant Professor, Agricultural & Biological Engineering

*Source:*

<https://www.johntevansiv.com/>

### **Analysis of energy efficient solutions for modern agricultural machines**

*Contact:*

Andrea Vacca, Maha Fluid Power Faculty Chair; Professor, Agricultural & Biological Engineering/Mechanical Engineering (joint), [avacca@purdue.edu](mailto:avacca@purdue.edu)

*Collaborators:*

Gary Kassen (CNH), Enrique Busquets (Bosch Rexroth)

*Source:*

<https://engineering.purdue.edu/Maha>

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## **Modeling and visualization tools for water management**

*Contact:*

Jane Frankenberger, Professor, Agricultural & Biological Engineering, [frankenb@purdue.edu](mailto:frankenb@purdue.edu)

*Collaborators:*

Laura Bowling, Professor of Agronomy

Keith Cherkauer, Professor of Agricultural and Biological Engineering

Darrell Schulze, Professor of Soil Science

*Sources:*

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<https://transformingdrainage.org/tools/drained-area/>

<https://iwrrc.org/indiana-water/>

<https://soilexplorer.net/>

## **Livestock**

### **Meat processing solutions for premium beef and profitability of U.S. beef: Enhancing the competitiveness and value of U.S. beef**

*Contact:*

Brad Kim, Associate Professor of Animal Science, [bradkim@purdue.edu](mailto:bradkim@purdue.edu)

*Collaborators:*

Bruce Cooper, Director of Metabolomics Facility, Purdue University

Jerrad Legako, Associate Professor, Texas Tech University

*Source:*

<https://ag.purdue.edu/ansc/Pages/Profile.aspx?strAlias=kim1689>

### **Development of new tools to detect unlabeled food components**

*Contact:*

Rebecca Wilkes, Assistant Professor, Molecular Diagnostics, Section Head for Molecular, Virology, and Serology Sections, Department of Comparative Pathobiology / Animal Disease Diagnostic Laboratory (ADDL), College of Veterinary Medicine, [rwilkes@purdue.edu](mailto:rwilkes@purdue.edu)

*Collaborators:*

Jobin Kattoor, Postdoctoral Fellow, Center for Plant Biology and ADDL

### **Forage testing is critical for healthy cattle and cost-effective operations**

*Contact:*

Nick Minton, Beef Systems Specialists, [nminton@purdue.edu](mailto:nminton@purdue.edu)

Keith Johnson, Professor of Agronomy, [johnsonk@purdue.edu](mailto:johnsonk@purdue.edu)

*Collaborators:*

Forage Analysis Testing Cost-Share Program

Ophelia Davis, Agriculture & Natural Resources Educator, Lawrence County

Soil and Water Conservation District, Lawrence County

Twilight Tour Area Field Day

Ophelia Davis, Agriculture & Natural Resources Educator, Lawrence County

Danielle Walker, Agriculture & Natural Resources Educator, Washington County

Brad Shelton, Superintendent, Feldun-Purdue Agricultural Center

Forage Quality Testing – A Wakeup Call for Clark County Ranchers

Simon Kafari, Agriculture & Natural Resources Educator, Clark County

Grazing 102

Kenneth Eck, Agriculture & Natural Resources Educator, Dubois County

Jason Tower, Superintendent, Southern Indiana Purdue Agricultural Center

Brad Shelton, Superintendent, Feldun-Purdue Agricultural Center

Grant Burcham, Veterinary Diagnostician, Animal Disease Diagnostic Laboratory /

Heeke Animal Disease Diagnostic Laboratory

Brooke Stefancik, Agriculture & Natural Resources and 4-H Youth Development Educator, Sullivan County

Mark Carter, Agriculture & Natural Resources Educator, Blackford County

## Horticulture and Natural Resources

**Toward more productive, profitable, sustainable controlled-environment agriculture: Producing crops effectively and economically in controlled environments**

*Contact:*

Cary Mitchell, Professor of Horticulture, [cmitchel@purdue.edu](mailto:cmitchel@purdue.edu)

**New tests for detecting bacteria on plant surfaces: Characterization of the lettuce microbial community by metagenomic sequencing and optical light scattering**

*Contact:*

Robert Pruitt, Professor of Botany & Plant Pathology, [pruittr@purdue.edu](mailto:pruittr@purdue.edu)

*Collaborators:*

M. Catherine Aime, Professor of Mycology and Director of the Purdue Herbaria

Euiwon Bae, Senior Research Scientist, School of Mechanical Engineering

Amanda J. Deering, Clinical Associate Professor of Food Science

Bartek Rajwa, Research Associate Professor, Bindley Bioscience Center

J. Paul Robinson, The SVM Professor of Cytomics, Professor, Weldon School of Biomedical Engineering, Director, Purdue University Cytometry Laboratories

**Growing Together provides fresh produce for limited-resource Indiana residents**

*Contacts:*

Blake Connolly, Assistant Director, Purdue Extension Nutrition Education Program (Lead for Indiana for Growing Together), [baconnol@purdue.edu](mailto:baconnol@purdue.edu)

John Orick, Purdue Extension Master Gardener State Coordinator, [orick@purdue.edu](mailto:orick@purdue.edu)

Stephanie Faroh, Training Specialist, Purdue Extension Nutrition Education Program, [faroh@purdue.edu](mailto:faroh@purdue.edu)

*Collaborators:*

Rosie Lerner, former Purdue Consumer Horticulture Extension Specialist

Jered Blanchard, Community Wellness Coordinator, Allen County

Terri Theisen, Horticulture Educator, Allen County

Holly Catron, Community Wellness Coordinator, Boone County

Curt Emanuel, County Extension Director, Agriculture & Natural Resources Educator, Boone County

Erin Meyer, Community Wellness Coordinator, Crawford & Spencer counties

Molley Scott, 4-H Youth Development Educator, Crawford County

Luis Santiago, County Extension Director, Agriculture & Natural Resources Educator, Daviess County

Ashlee Sudbury, Community Wellness Coordinator, Daviess County

Lindsey Cox, Community Wellness Coordinator, Delaware County

Laurynn Thieme, Agriculture & Natural Resources Educator, Delaware County

Gloria Del Greco, former Community Wellness Coordinator, Hamilton & Hancock counties

Lais McCartney, Agriculture & Natural Resources Educator, Hancock County

Rebecca Koetz, Agriculture & Natural Resources Educator, Lake County  
Theresa Mince, Community Wellness Coordinator, Lake County  
Lupe Valtierra, Community Development Educator, Lake County  
Chelsie Jaramillo, Community Wellness Coordinator, Madison County  
Beth Vansickle, Agriculture & Natural Resources Educator, Madison County  
Linda Adams, Community Wellness Coordinator, Marion County  
Steve Mayer, former Horticulture Educator, Marion County  
Terri Saltzman, Community Wellness Coordinator, Porter County  
Nicole Witkowski, Agriculture & Natural Resources Educator, Porter County  
Mindy Duckett, Community Wellness Coordinator, Putnam County  
Jenna Nees, Agriculture & Natural Resources Educator, Putnam County  
Nicholas Held, Agriculture & Natural Resources Educator, Spencer County  
Karen Mitchell, Agriculture & Natural Resources Educator, Tippecanoe County

**North Central Climate Collaborative (NC3): Action to address climate change for farm, operation, family, or community**

*Contact:*

Hans Schmitz, Agriculture & Natural Resources Educator, Posey County, [hschmitz@purdue.edu](mailto:hschmitz@purdue.edu)

*Collaborators:*

Austin Pearson, County Extension Director, Agriculture & Natural Resources Educator, Tipton County  
Melissa Widhalm, Operations Manager, Purdue Climate Change Research Center  
Beth Hall, Director, Indiana State Climate Office  
Jeffrey Dukes, Director, Purdue Climate Change Research Center, Professor of Forestry & Natural Resources and Biological Sciences  
Laura Edwards, State Climatologist, South Dakota State University  
Aaron Wilson, Climate Specialist, Ohio State University Extension  
Monica Jean, Extension Educator, Michigan State University Extension  
Peter Tomlinson, Associate Professor, Kansas State University

*Source:*

<https://northcentralclimate.org/>

**Managing emerald ash borer in urban and natural forests: Minimizing impact on the environment**

*Contact:*

Matthew Ginzal, Professor, Departments of Entomology and Forestry & Natural Resources, Director, Hardwood Tree Improvement and Regeneration Center, [mginzel@purdue.edu](mailto:mginzel@purdue.edu)

*Collaborators:*

Clifford Sadof, Professor, Department of Entomology.  
Linas Mockus, Research Associate Professor, Davidson School of Chemical Engineering.

Source:

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### Engaging family forest owner: Key to reducing invasive plant spread into forest ecosystems

Contact:

Zhao Ma, Professor of Natural Resource Social Science, [zhaoma@purdue.edu](mailto:zhaoma@purdue.edu)

Collaborators:

Stephanie Snyder, USDA Forest Service Northern Research Station

Kristin Floress, USDA Forest Service Northern Research Station

Mysha Clarke, University of Florida (former PhD student)

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## Food, Nutrition, Families and Health

### Facing mental health and building support in the community

Contacts:

Tonya Short, Health & Human Sciences Educator, Knox County, [short43@purdue.edu](mailto:short43@purdue.edu)

Curt Emanuel, County Extension Director, Agriculture & Natural Resources Educator, Boone County, [cemanuel@purdue.edu](mailto:cemanuel@purdue.edu)

Stephanie Woodcox, Assistant Program Leader for Purdue Extension, College of Health & Human Sciences, [swoodcox@purdue.edu](mailto:swoodcox@purdue.edu)

*Collaborators:*

Abigail Heidenreich, County Extension Director, Agriculture & Natural Resources Educator, Orange County  
Andrew Hays, Health & Human Sciences Educator, Gibson County  
Angela Sorg, Health & Human Sciences Educator, DeKalb County  
Britt Copeland, 4-H Youth Development Educator, Brown County  
Brittney Schori, Health & Human Sciences Educator, LaGrange County  
Bryan Overstreet, County Extension Director, Agriculture & Natural Resources Educator, Jasper County  
Elisa Worland, Health & Human Sciences Educator, Wayne County  
Elysia Rodgers, County Extension Director, Agriculture & Natural Resources Educator, DeKalb County  
Jane Horner, Health & Human Sciences Educator, Cass County  
Jonathan Ferris, County Extension Director, Agriculture & Natural Resources Educator, Wayne County  
Kelly Heckaman, Interim East District Director, Agriculture & Natural Resources Educator, Kosciusko County  
Kelsey Meyers, 4-H Youth Development Educator, Henry County  
Marcia Parcell, Health & Human Sciences Educator, Dearborn County  
Rachel Dillhoff, Health & Human Sciences Educator, Adams County  
Richard Beckort, Agriculture & Natural Resources Educator, Jackson County  
Robert Kelly, County Extension Director, Agriculture & Natural Resources Educator, Elkhart County  
Shannon Chipman, County Extension Director, Health & Human Sciences Educator, Ohio County

*Source:*

<https://api.ag.purdue.edu/api/DepotWS/File.ashx?t=f&i=100497>

**Exposure to the herbicide atrazine and influence on mental health pathways**

*Contact:*

Jennifer Freeman, Professor of Toxicology, School of Health Sciences, College of Health and Human Sciences, [jfreema@purdue.edu](mailto:jfreema@purdue.edu)

*Collaborators:*

Chongli Yuan, Charles Davidson Associate Professor of Chemical Engineering

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**Identifying bioactive food compounds and the molecular mechanisms controlling adipose development and obesity**

*Contact:*

Kee-Hong Kim, Associate Professor of Food Science, [kim618@purdue.edu](mailto:kim618@purdue.edu)

(<https://ag.purdue.edu/foodsci/Pages/profile.aspx?strAlias=kim618> )

Personal website: <https://sites.google.com/site/khkpurdue/>

*Collaborators:*

Bennett Elzey, Purdue Center for Cancer Research

Yeonhwa Park, Department of Food Science, University of Amherst, MA

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**The influence of cereal bran and bran arabinoxylan chemical and physical structure on the human gut microbiome**

*Contact:*

Stephen Lindemann, Assistant Professor, Food & Nutrition Science, [lindems@purdue.edu](mailto:lindems@purdue.edu)

*Source:*

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**Indiana adults take control of their personal finances**

*Contact:*

Naomi Bechtold, Extension Specialist, Family Resource Management, [nbechtol@purdue.edu](mailto:nbechtol@purdue.edu)

*Collaborators:*

Harriet Armstrong, Health & Human Sciences Educator, Bartholomew County

Cindy Barnett, former Health & Human Sciences Educator, Whitley County

Lori Bouslog, Health & Human Sciences Educator, Vermillion County

Lisa Cangany, Health & Human Sciences Educator, Boone County

Jay Christiansen, Health & Human Sciences Educator, Vigo County

Christopher Fogle, Health & Human Sciences Educator, Decatur County

Jaelyn Franks, Health & Human Sciences Educator, Kosciusko County

Jo Gilreath, Health & Human Sciences Educator, Warrick County

Molly Hoag, Health & Human Sciences Educator, Wells County

Molly Hunt, Interim East District Director, Health & Human Sciences Educator, Delaware County

Megan Jaspersen, Health & Human Sciences Educator, Perry & Spencer counties

Annetta Jones, County Extension Director, Health & Human Sciences Educator, Porter County



Molly Marshall, Health & Human Sciences Educator, Jackson County  
Mindy Mayes, Health & Human Sciences Educator, Wabash County  
Mandy Medbourn, Health & Human Sciences Associate Educator, Pulaski & Starke counties  
Daron Monnin, Health & Human Sciences Educator, Randolph County  
Kelsie Muller, County Extension Director, Health & Human Sciences Educator, 4-H Youth Development Educator, Benton and Warren counties  
Marcia Parcell, Health & Human Sciences Educator, Dearborn County  
Susan Peterson, County Extension Director, Health & Human Sciences Educator, Hamilton County  
Brittney Schori, Health & Human Sciences Educator, Whitley County  
Marilyn Sink, County Extension Director, Health & Human Sciences Educator, Scott County  
Demarcus Sneed, former Health & Human Sciences Educator, Madison County  
Angela Sorg, Health & Human Sciences Educator, DeKalb County  
Courtney Stewart, former Health & Human Sciences Educator, Monroe County  
Beth Switzer, County Extension Director, Health & Human Sciences Educator, Hendricks County  
Gail Wright, Health & Human Sciences Educator, 4-H Youth Development Educator, Parke County

### **Get WalkIN' participants increase their physical activity for health**

*Contact:*

Stephanie Woodcox, Assistant Program Leader for Purdue Extension, College of Health & Human Sciences, [swoodcox@purdue.edu](mailto:swoodcox@purdue.edu)

Elizabeth Richards, Associate Professor, School of Nursing, College of Health & Human Sciences, [earichar@purdue.edu](mailto:earichar@purdue.edu)

*Collaborators:*

Health & Human Sciences Educators

## **Youth Development**

### **Youth design technology to solve real-world issues**

*Contact:*

Rachel Haselby, 4-H Youth Development Extension Specialist - Computer Science, [rhaselby@purdue.edu](mailto:rhaselby@purdue.edu)

*Source:*

[https://api.ag.purdue.edu/api/DepotWS/File.ashx?t=f&i=102699&\\_ga=2.152351289.1478982302.1620748195-1363517616.1591617854](https://api.ag.purdue.edu/api/DepotWS/File.ashx?t=f&i=102699&_ga=2.152351289.1478982302.1620748195-1363517616.1591617854)

### **Soccer & 4-H @ Home keeps youth active**

*Contact:*

Xiomara Diaz-Vargas, 4-H Youth Development Extension Specialist - New Audience Initiatives, [xdiazvar@purdue.edu](mailto:xdiazvar@purdue.edu)

*Collaborators:*

Rachel Rawls, County Extension Director, 4-H Youth Development Educator, St. Joseph County  
Gayle O'Connor, 4-H Youth Development Educator, LaPorte County  
Laura Valencia, Extension Agent II 4-H, Osceola County, UF/IFAS Extension

**Indiana 4-H teens grow in leadership**

*Contact:*

Steve McKinley, 4-H Youth Development Specialist - Leadership and Volunteerism, [mckinles@purdue.edu](mailto:mckinles@purdue.edu)

*Collaborators:*

Jennifer Monarch McGuire, 4-H Youth Development Educator, Tippecanoe County  
Sthele Greybar, 4-H Youth Development Educator, Elkhart County  
Rachel Rawls, County Extension Director, 4-H Youth Development Educator, St. Joseph County  
Kelsey Guadarrama, 4-H Youth Development Educator, Marshall County  
Karin Gilbert, 4-H Youth Development Educator, St. Joseph County

*Source:*

<https://extension.purdue.edu/4h/Pages/SJLC/SJLC-resources.aspx>  
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**Food safety training for high school**

*Contact:*

Yaohua Betty Feng, Assistant Professor of Food Science, [yhfeng@purdue.edu](mailto:yhfeng@purdue.edu)

*Collaborator:*

Hui-Hui Wang, Assistant Professor of Agricultural Sciences Education and Communication

*Sources:*

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## Community and Business Development

### On local government: COVID-19 Response

*Contact:*

Tamara Ogle, Community Development Regional Educator, [togle@purdue.edu](mailto:togle@purdue.edu)

*Collaborators:*

Mary Foell, Community Development and 4-H Youth Development Educator, LaPorte County

Lupe Valtierra, Community Development Educator, Lake County

Janet Reed, former County Extension Director, Lake County

Kristi Whitacre, Community Development Educator, Vigo County

Amanda Mosiman, Agriculture & Natural Resources Educator, Warrick County

Cynthia Barber, Community Development Educator, Daviess County

Molly Hunt, Interim East District Director, Health & Human Sciences Educator, Delaware County

Cheri Brown, County Extension Director, Blackford County

Krista Pullen, Community Development and Agriculture & Natural Resources Educator, Cass County

*Source:*

COVID-19 Resources for Local Governments, <https://cdext.purdue.edu/collaborative-projects/olgcovid19/>

### Navigating difference and cultural awareness workshops build cultural competence for Hoosiers

*Contact:*

Kris Parker, Community Development Regional Educator, Northwest District, [parkerkj@purdue.edu](mailto:parkerkj@purdue.edu)

*Collaborators:*

Xiomara Diaz-Vargas, 4-H New Audiences Specialist

Samuel Johnson, 4-H Youth Development Educator, Allen County

William Horan, County Extension Director, Agriculture & Natural Resources Educator, Community Development Educator, Wells County

Marcia Parcell, Health & Human Sciences Educator, Dearborn County

Steve Yoder, Community Development Regional Educator, Central District

Amy Nierman, District Director, Southeast District

Heather VonDielingen, County Extension Director, 4-H Youth Development Educator, Jackson County

Bob Bruner, Agriculture & Natural Resources Educator, Clay & Owen counties

Tamara Ogle, Community Development Regional Educator, East District

Luis Santiago, County Extension Director, Agriculture & Natural Resources Educator, Daviess County

Brittney Schori, Health & Human Sciences Educator, LaGrange County

Laurynn Thieme, Agriculture & Natural Resources Educator, Delaware County

Amanda Dickson, International Extension Specialist

*Source:*

<https://cdext.purdue.edu/signature-programs/leadership-civic-engagement/navigating-difference/>

**Green infrastructure in the North Central Extension Region: Building an equitable and just strategy and workforce**

*Contact:*

Kara Salazar, Assistant Program Leader and Extension Specialist for Sustainable Communities, [salazark@purdue.edu](mailto:salazark@purdue.edu)

*Collaborators:*

Steve Yoder, Community Development Regional Educator, Central District

*Source:*

<https://northcentralwater.org/green-infrastructure/>

**Community development: Turtle Mountain Reservation's substance use disorder recovery center**

*Contact:*

Michael Wilcox, Community Development Program Leader, [wilcox16@purdue.edu](mailto:wilcox16@purdue.edu)

*Collaborators:*

Nicole Adams, Clinical Assistant Professor, School of Nursing

Aaron Thompson, Assistant Professor, Landscape Architecture Program, Director, Center for Community & Environmental Design, Department of Horticulture & Landscape Architecture, College of Agriculture