

## Iowa (Iowa State University) Annual Report - FY2021

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### Contributing Organizations

Iowa State University

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### Report Status

#### NIFA REVIEW

#### Comments

No comments added

### Executive Summary

#### Overview

Agriculture in the state of Iowa has grown beyond traditional production of crops and livestock to encompass the bioeconomy, life sciences, food sciences, value-added products, environmental sciences, and social sciences. Iowa's world-class endowment of natural resources, our highly skilled and educated people, and our well-developed infrastructure support a diverse and dynamic set of food, feed, fiber, biofuels and bioproducts, environmental, and community endeavors.

Iowa's abundance is astonishing, ranking second nationally (behind California) with cash farm receipts (2020) of \$28.36 billion. This position is the result of Iowa's strong ranking in the production of several commodities. In 2020, Iowa was the nation's largest producer of corn, pork, eggs, and ethanol; second in soybeans; fifth in cattle production; sixth in turkey production; and 11th in dairy. Iowa had 86,104 farms operating on 30,563,878 acres in 2017. Cropland accounts for 87 percent of Iowa's total farm acres (2017). The average farm size in Iowa is 355 acres, while the median farm size is 142 acres (2017).

Iowa had 3,193,079 residents in 2021, ranking 31st among states in total population size. The state's nine metropolitan statistical areas (MSAs) include 22 of its 99 counties and 61 percent of its total population (2020). Iowa's 39 percent non-metropolitan population share is 9th highest among states. Slightly more than one-third (36 percent) of Iowa residents live in a rural territory with fewer than 2,500 inhabitants, ranking 11th among states (2019).

The Hispanic/Latinx population, which includes people of any race, is the largest minority group in Iowa, accounting for 6.8 percent of the population in 2020. The Black or African American population, both Latinx and non-Latinx, is the second-largest minority group with 4.1 percent of residents. The Asian population is third with 2.4 percent (2020). Iowa's non-Latinx white alone population accounts for 82.7 percent of the total population (2020). The poverty rate for individuals in Iowa was 11.2 percent (+/- 0.5%) in 2019, compared to a rate of 12.3 percent (+/- 0.1%) in the United States. Minority students comprised 28.3 percent of PreK-12 public school enrollment in 2021-22, compared to 10.4 percent in 2001-2002.

Continuing demographic changes, globalization, and technological innovations create ongoing opportunities and challenges toward achieving socially beneficial, economically successful, and environmentally sound systems for food, feed, fiber, fuel, and other value-added products. To this end, we have identified six, long-term critical issues that our research projects and extension programs are designed to address:

- Food Production and Agricultural Systems
- Natural Resources and Environmental Stewardship
- Community and Economic Development
- Health, Nutrition, and Well-being
- Human Potential and Youth Development

- Transformative Technology

Research is conducted across most disciplines in agriculture, defined in its broadest sense, from foundational to applied, to make advances in production, to help increase capacity, and to provide an adequate and nutritious food supply. The research expressed in the program areas is the result of cooperation among researchers within and between departments and colleges at all levels of activity. Hatch and Smith- Lever capacity grants provide critical funding for starting that ultimately allows us to leverage and match other external funding sources. The capacity grants also provide flexibility in programming to better and more quickly meet current and emerging needs not being addressed by other sources of funding. Without these funds, there would be less applied research, less real world application of research, and less integration of extension and research work.

### **Critical Issue: Community and Economic Development**

Over half of Iowa farmland is owned by someone who does not currently farm. Of that land, 34 percent is owned by owners with no farming experience and the remaining 24 percent is owned by retired farmers (Farmland Ownership and Tenure Survey). In today's rental market, approximately 30-40 percent of crop revenue goes towards farm rental expenses. Leasing arrangements are a top concern for Iowa producers and farmland owners. Rental agreement negotiations can be tense at times. In response, ISU Extension and Outreach ANR specialists served as an unbiased, research-based source of farmland leasing education. In this project period social distancing was observed in 31 in-person educational sessions, attended by 496 individuals. Sixty percent were non-farming landowners, 19 percent active farmers, 7 percent ag professionals. Through this effort and numerous others, direct contacts totaled 856 in 2020. Numerous local, regional, and statewide online sessions were held and recorded. These were attended by 117 and later viewed by hundreds more.

Of the 856 direct participants in these educational programs, 599 were invited to complete a post program evaluation. Approximately 95 percent of participants self-reported an increase in knowledge of leasing and legal issues and/or cash rental rates. Eighty-eight percent self-reported an increase in confidence to create meaningful change in their lease agreements.

Another Community and Economic Development effort is the Iowa Small Towns Project (ISTP), an integrated research and extension effort to better understand the conditions and issues facing small Midwestern communities and to provide support for the development of uniquely tailored activities to address the issues they face.

As a part of this project, a team of ISU scientists worked with six small towns with declining populations to discuss the results of his survey of households in 99 small towns in Iowa and identify priorities for their towns. He disseminated 73 town-level profiles, based on a large-scale survey. The profiles document the health and economic impacts of COVID-19, for communities' use in local planning and response efforts. He also worked with community groups in four meatpacking communities to demonstrate how to use the profiles to advocate for workplace health, safety and economic improvements for black, Indigenous and people of color (BIPOC) and meat packing workers. As a result of his and others' efforts, In Sac City, Iowa, the local development agency received a \$20,000 Iowa Economic Development Authority grant for a feasibility study for reuse of the soon-to-be-shuttered middle school building and adjacent green space. In Elma, the town received a \$1.2 million fund drive for conversion of an elementary school building into a community center for a new public library and childcare center. And in Bancroft, they pooled resources for a building to house a grocery store and a new distillery to bring in tourism. The ISTP survey data, town profiles, and focus groups helped identify these as priorities and helped secure the grants and fundraising efforts.

The economic recession of 2007-2009 and business challenges since then have increased the need to better understand rural small business ownership (e.g., types of assistance needed, strategic options, new ways to compete in today's marketplace). Successful locally-owned businesses can enhance rural development and improve quality of life through their catalytic activities associated with economic development, entrepreneurship, and the development, marketing, and distribution of consumer related offerings. In one project this period, a researcher focused on ways to enhance the entrepreneurial potential of two, sizable, but underserved populations in Iowa: women and older residents ages 50+, to engage in the start-up of food/hospitality-related (e.g., restaurants, local food vendors) and fiber-related (e.g., textile and apparel soft goods) businesses. Their previous research has shown these retail and service-based businesses to have helped to diversify and strengthen the economic base and character of many rural communities.

Interview and survey research this period determined environmental factors (e.g., community support, industry readiness and competition, available business assistance, and business/technology infrastructure) that are perceived to facilitate or deter the start-up of new food and fiber related business ventures for women and individuals age 50+. We also identified individual factors (e.g., personal attributes, motivations, family support) that are perceived to support or discourage business start-up for women and individuals age 50+ in Iowa.

In-depth interviews with the emphasis of the underserved groups' needs on education, training, and assistance were conducted with four small food business operators in Fairfield, Iowa. Interview data was assessed and adopted to create training videos. Videos were initially delivered in either face-to-face or online

sessions with 10 business operators. The training videos were later made accessible to Extension professionals and residents across the 99 counties of Iowa.

Through refereed and invited presentations, publications, grant proposals, and student-learning activities, the team increased knowledge and provided strategic information to academic researchers, business/economic development specialists, and businesses owners about new approaches for improving economic well-being and business sustainability in rural Iowa communities.

### **Critical Issue: Food Production and Agricultural Systems**

The thermal properties of soil affect many important soil attributes, including evapotranspiration, infiltration, water storage for plant use, drainage and how chemicals move in soils. Scientists have been studying soils for a long time, but this is an area where they are still learning. This year Robert Horton, who holds the Charles F. Curtiss Distinguished Professorship in Agriculture and Life Sciences in agronomy at Iowa State University, is one of the senior scientists recognized by USDA with its national Multistate Research Excellence Award for 2021 for his part in the long-running project, "Soil, Water and Environmental Physics to Sustain Ag and Natural Resources, or better known as W4188. This year, the team, including graduate students and a group of faculty, developed a new dual-probe heat pulse sensor to simultaneously measure soil thermal properties, soil water content and soil water matric potential. A series of experiments were performed to evaluate the sensor performance. The new sensor effectively measured soil water matric potential, soil water content, and soil thermal property values. Over time, scientists learned they could garner much more information from the sensor, such as heat energy moving in and out of soil and how much ice is forming or melting in soil, something we don't believe any other sensor can do. It can also measure bulk density to help gauge soil compaction and how it changes and impacts other soil conditions over time. The Thermo-TDR tool is primarily being used now by researchers for field measurements. The data it provides are also being used to improve modeling that forecasts how soil conditions change over time in response to changes in weather and climate. This is the first step toward developing a commercial sensor that can be broadly used to monitor soil water status.

Accurate weather forecasts for the US Corn Belt allow farmers to identify optimal periods of planting and harvesting, and lead to more accurate predictions of harvest yields. ISU researchers are working to improve weather and climate forecasts made by using satellite observations of soil moisture in the first few centimeters of the Earth's land surface. Soil moisture is important because it influences how water and energy move between Earth's surface and atmosphere, thus affecting weather and climate. This FFY, one of our research groups used soil moisture measurements from two relatively new satellites: NASA's Soil Moisture Active Passive (SMAP) mission; and the European Space Agency's Soil Moisture Ocean Salinity (SMOS) mission. This project year, they were able to confirm that satellite soil moisture observations are more often accurate in regions of the state with fewer row crops and less often accurate in regions of the state with more row crops. Data from this study advances the science needed to improve the satellite algorithms.

Understanding how genome stability is maintained and how genomic changes occur is important for modern agriculture, which relies of genomic manipulation, whether by conventional breeding, recombinant DNA technology, or genome editing, to generate novel strains of plants and animals. Much has been learned about the composition (DNA sequence) of the genomes of important agricultural species. However, there are important aspects of the functioning of genomes that are not well understood. In one project this year, we investigated how epigenetic modifications of chromatin proteins carried out by the JIL-1 kinase affect the systems that control mutation, recombination, and the repair of DNA double strand breaks (DSB). DSB are serious threats to genome stability. A single unrepaired DSB can cause death or significant developmental damage to a cell, so they must be repaired to restore genomic integrity. Our studies this year confirmed that JIL-1 has a role in DSB repair. This finding is a significant contribution to the scientific understanding of genome structure, function, and stability. No similar study has been done before.

Poultry provides a major animal protein source for human diets. The US industry must continue to genetically improve the production stocks and needs fundamental scientific information about the genetic control of important biological traits in order to do so. One project team at ISU determined that genetic lines of chickens that are relatively more resistant or susceptible to avian influenza virus have different expression of genes related to immune function, especially the interferon pathway. They developed a genotyping platform to analyze African chicken lines and determined that there are multiple regions of the genome each explaining over one percent of the response to Newcastle Disease Virus. They demonstrated moderate heritability of several important biological traits in these chicken populations. This new scientific knowledge enabled other scientists to begin to build future studies on this information. Poultry breeding companies can use this information within their in-house programs for animal genetic improvement. Future application of this information will increase efficiency in production of eggs and chicken meat, resulting in better food security.

In 2019, major packers announced Beef Quality Assurance Transportation (BQAT) certification would be required for all beef cattle transporters and producers directly delivering cattle to their packing plants. Iowa State University Extension and Outreach Beef Quality Assurance (BQA) program expanded in response to this. In 2019, 198 BQAT participants were certified in eight separate trainings. To measure the impact of the BQA and BQAT training, a survey was administered late in 2019 through mid-2020 to participants attending seven unrelated beef programs across the state. This sampling strategy yielded completed surveys from 146 producers representing various segments of the beef industry (41% cow-calf, 5% stocker, and 60%

feedlot). Because of overlap, these percentages total over 100 percent. Respondents were asked what changes they made in their operation as a result of BQA and BQAT training. Forty-nine percent changed their cattle handling or processing area, which improves both cattle welfare and productivity. One producer summed it up well, "Continue to handle cattle quietly and try to get other people to treat cattle quietly." Forty percent changed their cattle health program, improving both animal health and profitability. Thirty-four percent shared with consumers how they manage their cattle to provide high-quality, healthy beef.

In Iowa, about 23 million acres are annually planted with corn and soybeans. The fertility costs of an acre of corn average over \$100, and for soybeans approximately \$54 per acre. Utilizing farm inputs effectively can make a big impact on the cost of production and economic efficiency of crop production. Additionally, there are significant environmental concerns regarding nutrient loss when nutrient applications are placed incorrectly and when nutrients are over-applied. The objective of our statewide soil fertility workshops is to help producers understand how to wisely spend dollars to maintain high yields, reduce unnecessary expenditures, and protect soil and water quality while increasing farmer and landowner skills in interpreting soil test results and increasing farmer and landowner confidence in formulating their own soil fertility plan based on interpretation of the soil test results. The target audience for our soil fertility workshops includes farmers, landowners, and industry professionals. Understanding and implementing soil fertility recommendations ranked as the highest need in the five choices of programs offered to our target audience via a needs assessment. As a result of this needs assessment, field agronomists developed learning objectives, curriculum, worksheets, and teaching slides. Additional resources such as ISU fact sheets were identified and provided as supplemental handout materials to aid in decision-making. Workshops used ISU research-based recommendations and local agronomist knowledge to deliver relevant, hands-on information via 17 in-person workshops in 2019 and 2020, and via two virtual workshops held in early 2021. Workshops reached 225 people and plans exist to continue this effort now that COVID restrictions are lifted. This audience benefits from these workshops by being able to more effectively use dollars allocated for crop nutrition by placing them where they are needed, thereby reducing over-application, while maintaining yields that maintain farm income.

### **Critical Issue: Health, Nutrition and Well-being**

Among the estimated two million agricultural workers in the United States, physicians diagnose 10,000 to 20,000 pesticide poisonings each year. The National Institute for Occupational Safety and Health (NIOSH) established the Sentinel Event Notification System for Occupational Risks – Pesticides Program (SENSOR-Pesticides) in 1987 to reduce the number of injuries and illnesses associated with occupational pesticide exposure. Among persons exposed to insecticides, the chemical classes most often involved are pyrethroids, organophosphates, sulfur compounds, and pyrethrins. Organophosphates (OPs), nerve agents, are a class of lethal weapons of mass destruction that kill by disrupting the nerve transfer mechanism. Unfortunately, these highly adhesive and volatile nerve agents are colorless, odorless and tasteless, making detection very difficult.

In order to address detection challenges, we developed novel nanofiber-based sensors to detect the pesticides for chemical protective clothing. This research addresses the urgent need of safety protection for farmers and personnel working in hazardous environments, including firefighters and soldiers.

In other research, a study of rural Iowa Latinx immigrant families revealed that workplace conditions and lack of access to adequate health care services placed Latinx immigrant parents at risk of being exposed to COVID-19 and spreading the virus to family members and others. The same study found that faith, emotional and tangible support from family members, friends, local churches, and adhering to health advice (e.g., wearing masks, social distancing as feasible, etc.) helped safeguard families' health and wellbeing during the pandemic.

In other research, we developed and tested novel community interventions to improve diet in Latinx populations and children living in rural areas of the state. New approaches for processing milks and developing emulsions that aid in the creation of healthier food products were investigated and the results communicated to industry partners.

Our university has a long-standing relationship with communities in Uganda. About 38 percent of Ugandan children under 5 years old are clinically deficient in vitamin A. Vitamin A is needed to support the immune system. Children who are deficient have a higher risk of dying from infectious diseases such as diarrhea or measles. This year, our research was able to confirm the bioavailability of pro-vitamin A in enriched bananas, as a dietary intervention to alleviate vitamin A deficiency in Ugandan children under the age of five.

Our SNAP-Ed and EFNEP programming, in nutrition education and healthy food access, reached 730 adults via 5,228 direct education sessions in 14 counties. In post-attendance surveys, youth and adults reported the following results: youth increased their frequency of vegetable consumption by 33 percent and fruit consumption by 38 percent; adults increased their frequency of vegetable consumption by 46 percent and fruit consumption by 30 percent.

Servsafe® is a food safety training program developed by the National Restaurant Association to provide food service workers with the knowledge they need to protect the public from foodborne illnesses. In 2021, our Servsafe® workshops were offered in every region of the state and were attended by 2,033 Iowans. Seventy-seven percent were able to obtain certification.

As a part of a research project, we conducted mosquito and tick surveillance in the state of Iowa to better understand the abundance and ecology of these arthropod vectors and the diseases that they transmit. When paired with the long-term data set of surveillance efforts from previous years, these data can inform trends in vector abundance and vector-borne disease transmission risks. In addition to generating reports for local and state public health officials, mosquito and tick surveillance results were disseminated through local, regional, and national databases to serve the greater community of public health professionals, mosquito control professionals, and academic researchers interested in medical entomology and disease ecology. Results were also shared with other members of the Upper Midwest Center of Excellence in Vector Borne Disease, initiating conversations of vector-borne disease surveillance outside of traditional state borders.

### **Critical Issue: Human Potential and Youth Development**

Our educational program entitled “Essentials to Child Care” has been added to state licensing requirements for all Iowa childcare teachers and providers. With the childcare workforce turnover reported at 35-55 percent annually, demand for this online education program is high. This FFY, a total of 6,697 unique individuals completed one or more of the 12 modules successfully. Participants received a certificate for each module successfully completed. Examples of module topics include “How to Create a Safe Environment for Young Children,” “Prevention and Control of Infectious Diseases,” and “Supporting Cultural Diversity.” Childcare providers who complete certification through this course benefit from accreditation in their field and competence in skills related to their profession.

Misinformed income-tax filers miss out on benefits they are entitled to. A trained tax preparer can help filers avoid missteps, however, the average tax preparation fee was \$175 in 2021, making these services unaffordable for many Iowans.

The IRS’s Volunteer Income Tax Assistance (VITA) program offers free tax help to people who make \$54,000 or less, persons with disabilities, the elderly and limited English-speaking taxpayers who need assistance in preparing their own tax returns. IRS-certified volunteers provide free basic income tax return preparation with electronic filing to qualified individuals. In FFY21, three of our program specialists trained 68 volunteers to complete the IRS certification exams required for assisting others with tax preparation. Also, through outreach and administrative support, thirteen county extension offices across Iowa assisted nearly 1400 Iowans with low- and moderate-income to access free, accurate tax preparation and to connect to critical tax credits.

According to the National Alliance on Mental Illness (NAMI), in February 2021, 42 percent of Iowa adults reported symptoms of anxiety or depression. Of the 154,000 adults in Iowa who did not receive needed mental health care, 29 percent did not because of cost. Similarly, 58 percent of Iowa youth aged 12-17 who had depression did not receive any care in the last year. In Iowa, 490 lives were lost to suicide and 129,000 adults had thoughts of suicide in the last year. In response to the needs of Iowans to provide care and support for friends and family members who experience mental illness, we offer education through Extension and Outreach programs. In this FFY, we reached 295 participants in 22 virtual workshops entitled Mental Health First Aid. Each workshop included 6-hours of instructor-led education and two hours of pre-course work. Our workshop entitled “Question, Persuade, Refer,” was offered in 19 one-hour online workshops and one in-person workshop. A total of 224 Iowans participated. Participants include agribusiness professionals and producers, commodity group representatives, mental health advocates, formal and informal educators, and laypeople. In the post-course assessment, 88 percent of participants agreed or strongly agreed they feel more confident in asking anyone directly whether they are considering killing themselves. Participants also increased their knowledge and confidence in using action plans to refer an individual in crisis, or who may be suicidal, to appropriate professional resources.

The 4-H Youth Mental Health Survey administered by the National 4-H Council in 2020 reported that 82 percent of youth wished America would talk more openly about mental health (National 4-H Council, 2020). Also in 2020, a Center for Disease Control and Prevention study indicated rates of suicide among youth and young adults ages 10-24 increased 57 percent between 2007-2018 (Curtin, 2020). Stress can also increase participation in risky, unhealthy behaviors. Research shows daily mindfulness practices can have a significantly positive impact on a person’s overall health and wellness, including mental and physical health (Creswell, 2017). Iowa’s 4-H program offers workshops to help teens use mindfulness for better focus and concentration, improved self-awareness and regulation, increased empathy, compassion, and understanding, decreased stress, anxiety, and depression, increased self-esteem and improved sleep, relationships, and performance in school, work, sports, and other activities. The course is entitled “Mindful Teen: From Surviving to THRIVING!” It is a six-session curriculum based on the book, *The Mindful Teen: Powerful Skills to Help You Handle Stress One Moment at a Time*. In FFY21, 691 youth in 14 different counties participated in the training. Youth who engage in the Mindful Teen program indicate they have effective strategies to cope with stress and possess new strategies to address emotional highs and lows.

### **Critical Issue: Natural Resources and Environmental Stewardship**

Our Master Conservationist Program aims to increase knowledge of Iowa's ecosystems and knowledge of conservation practices that help sustain and protect Iowa's natural resources. Participants are encouraged to share what they learn with people in their communities.

Each year, several counties throughout Iowa organize and lead the Master Conservationist Program. The seven-week program is laid out in a flipped classroom style. Participants watch recorded lectures and complete assigned readings before attending in-person field sessions with natural resources professionals. Topics covered in the program include understanding Iowa's ecosystems such as prairies, forests, and watersheds; land and water conservation in Iowa; and how to plant seeds of conservation in their communities. After completing the online modules, each person participates in a field day with a local conservation professional.

In 2021, each participant was sent two online surveys; one at the start of the course to assess knowledge, and one after completion of the field day. Ninety-seven percent of respondents to the post-course assessment reported the online materials "improved their learning experiences in the program." To measure planned changes in land use and resource stewardship behaviors resulting from participation in the program, participants were asked if they planned to implement practices or principles learned on land they own or have influence over. All 91 respondents who answered this question replied "yes."

When temperatures and humidity begin to rise, Iowans head to the waters of Iowa to swim, boat and fish. Iowa has an abundance of parks and water bodies available for recreation. Iowa's park system is one of state government's most popular programs. Visitations skyrocketed to a record 16.6 million last year, amplifying an upward trend since 1995. In a state where most of the land is used for agriculture, research and extension targeting the preservation and, in many cases, restoration of water quality is extremely important.

In Iowa's 2020 impaired water listing, the most recent assessment of Iowa's waterbodies, only one percent of water segments assessed achieved all water quality standards for their designated use. This reality is also expressed nationally. Iowa is one of the major contributors to the Gulf of Mexico Hypoxic Zone, an area of very low oxygen that has resulted from farm nutrients like nitrogen and phosphorus being deposited in high concentrations into the Mississippi River and its tributaries. In 2012, Iowa developed the Iowa Nutrient Reduction Strategy (INRS), a statewide effort to reduce nitrogen and phosphorus loads. Iowa State University research and extension have several projects and programs to assist with the work needed to reach the goals of the INRS. Some 2021 activities and results follow below:

An analysis of optimal nitrogen (N) applications in Iowa under abnormal rainfall was completed. We found the profitability penalty for incorrect nitrogen application doubles under abnormal rainfall. As a result, environmental damages and environmental protection costs increase. Results were published and presented at a regional conference of producers, agribusiness, and scientists. The anticipated outcomes of this work are a reduction in producers' uncertainty associated with costs and benefits of conservation practices, and a resulting increased adoption of those practices.

Three drainage water quality studies documented nitrate-N loss reductions of 20-40 percent. Reduction was proportional to cover crop biomass growth. Two drainage water quality studies showed there is little difference in nitrate loss between fall nitrogen application and spring nitrogen application when fall N application occurs when soils are 50 degrees Fahrenheit and cooling. Results from five years indicate a statistically significant reduction in nitrate-N concentration when split N application is used.

One new saturated buffer was established on private land in Buena Vista County, IA. This new site, along with ongoing research at 16 sites installed across Iowa investigated the effectiveness of saturated buffers in removing nitrate. In total, over 50 total site-years of data have been collected as part of this research. Water flow and nitrate in the tile outlets, diverted into the buffers, and nitrate concentration changes within the buffers were monitored throughout the year at each site. Results showed that all the saturated buffers were effective in removing nitrate from the tile outlet. The annual removal effectiveness ranged from 12 to 92 percent. The project also identified barriers to farmer adoption of this and other practices.

Specific outcomes regarding several practices were detailed in a report to Iowa's Nutrient Research and Education Council. This new knowledge was also shared with vested stakeholder groups, direct contact with farmers and farmland owners through research being conducted on their farms; presentations at field days, conferences, ISU Extension trainings, and webinars; and through ad hoc meetings and direct consultation. Results have also been disseminated through peer-reviewed journal articles.

In 2021 we held two Iowa Watershed Academies for current Iowa watershed coordinators. The fall Academy focused on edge of field practice outreach, surveying, and cover crop management. A post-Academy survey was sent out to the 30 participants of the fall Academy; 67 percent responded. Eighty-five percent reported they agree or strongly agree they learned something valuable about edge of field practice surveying, 75 percent reported they agree or strongly agree they learned something valuable about cover crop management, and 70 percent reported they agree or strongly agree they learned something valuable about strategies for outreach and being a successful watershed coordinator.

In one research project, researchers created a tool to integrate enclosed depressional wetlands (often called "prairie potholes") into watershed conservation plans. Prairie potholes can serve as natural sponges that hold excess rain and snowmelt, thereby reducing the risk and severity of downstream flooding. In Iowa, many prairie potholes are used for cropland. Originally, scientists instrumented a total of seven prairie potholes and monitored ponded water depth during the growing seasons of 2016-2019, which allowed us in this project period to assess the frequency of flooding, spatial extent of ponding when flooded, and duration of ponding

events. Water quality was monitored daily during days of inundation greater than 10 cm in depth from 2016-2018. For the two potholes that were part of this original project, the depth and quality data have been uploaded to the EPA Water Quality Portal, which makes them publicly available.

Researchers then developed a tool and a strategy to assess the connections of prairie potholes located downstream of water bodies (to clarify whether these depressional wetlands should be defined as "Waters of the U.S." as per the Clean Water Act) and include impacts of enclosed depressions in watershed planning efforts. The tool developed under this project has been posted on the web, along with training materials, and presented to the scientific and lay communities through public and institutional webinars.

Farmers now have a dedicated tool to investigate whether management changes to their farming of prairie potholes may reduce the risk of flooding, or in the case of land retirement options may reduce the risk of economic losses due to flooding. Extension specialists, crop advisors, and other consultants can also use this tool. Policymakers and decision-makers have a method to potentially integrate prairie pothole restoration efforts into watershed protection plans. Producers and planners have another tool in their toolbox for protecting water quality in the Waters of the U.S.

### **Critical Issue: Transformative Technology**

In 2012, a team of three Iowa State University scientists developed PhenoBot, a state-of-the-art image-based platform for tall biomass crops to generate large data sets of plant architecture traits during the entire growing season. In FFY21, efforts were put into the improvements of the PhenoBot design, instrumentation, navigation control, and the redesign of our 3D stereo vision module: PhenoStereo. In addition to new algorithms for maize plant stalk size sensing and leaf angle measurement, new algorithms for maize plant leaf area sensing and soybean plant seed pod characterization are being developed.

Understanding soil-tool interaction can enable better control of weeding tools to achieve higher weeding efficacy. The interaction between a vertical tine mounted on a rotating disc and soil was investigated using a mathematical model that estimated soil horizontal forces on the tine operating at different linear and rotational velocities. The research showed that the variations in shear and inertial forces on the tine were due to differences in soil failure patterns across the treatments. Predicted forces for two tines using the model showed trends that were similar to the forces measured in the experiment. These results are helpful for the development of physical weeding tools that have weed control efficacies similar to those of chemical weed control approaches without the need for costly and dangerous inputs.

A new state-of-the-art off-highway vehicle chassis dynamometer was installed at the ISU Agricultural Engineering and Agronomy Research Farm. What does a dynamometer do? This specialized, large-scale equipment enables controlled, dynamic testing of complete off-highway vehicles with advanced traction control systems. Our facility is designed to test vehicles up to 450 kW (600 Hp), with speeds of up to 80 km/h (50 mph) and offers independent monitoring and loading of each wheel. The chassis dynamometer will be one of the few facilities capable of testing large construction and farm machinery. Possible tests: fuel-to-wheel energy efficiency, drawbar power test, high speed test, dynamic braking test, simulation of uphill/downhill driving and braking, hill cresting test, and startup torque test.

In related agricultural vehicle work, hydrostatic and hydro-mechanical transmissions are commonly used in off-highway vehicles. While both transmission technologies can provide continuously variable torque or speed ratios, they suffer from poor efficiencies and limited operating ranges. Electric variable transmissions, in contrast, offer complementary strengths via higher efficiencies at low forward and reverse speeds, full torque from zero to full power, and increased control capabilities. A physical modeling methodology was developed to explore different power-split transmission technologies using hydraulic, electrical, and mechanical pathways to understand how the complementary nature of the technologies could be used for overall power transmission performance.

Results from all our experiments have been distributed through traditional methods of peer-reviewed publications as well as directly to agricultural producers. The applied nature of this research is well suited for joint distribution both to the scientific community as well as direct distribution to producers and retailers who can immediately implement this new knowledge. Of particular interest was the focused delivery of planting systems and fertilizer application technology information directly to ag retailers through a series of extension and outreach meetings. Feedback from these meetings documented both the high value of this research effort as well as the timely nature of these results which helped to address several short-term challenges for producers and retailers. This information has since been incorporated into internal training and best practice materials for over a dozen ag retailers, crop service providers, ag equipment dealers, and insurance companies in the Midwest. On an annual basis this approach to "train-the-trainer" will help ensure the long-term impact and use of these results to enhance agricultural productivity and environmental sustainability.

Use of whole-genome (genomics) tools and perspectives to improve the genetics of U.S. animal-based commodities has been adopted by nearly all food and fiber animal-breeding industries. The constant advancement of next-generation sequencing (NGS) technologies coupled with the exponential decreases in sequencing costs, have produced seismic shifts in research approaches and have substantially broadened the scope of animal genomics. Harnessing the power of big data in agri-animal genomics research is only possible through coordinated teamwork efforts such as those successfully exhibited by the NRSP-8 species consortia. We have developed new genomic information, including data on genetic variability and functional genome

annotation, as well as increased public access to such data and shared tools and resources. Due to this effort in coordinating scientists across multiple stations, we increased the knowledge of genome function for pig and other domestic animal species. This is documented in the many papers published and meetings attended in the past year. This information can be used by at universities and breeding companies to analyze their animal's genetic makeup and accelerate genetic improvement.

## Merit and Scientific Peer Review Process

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### Updates

As the pandemic and other challenges continued in 2021, ISU Extension and Outreach focused additional effort and resources to help Iowans and their communities move forward in every county.

- 44 counties are focusing on reviving the Iowa economy, including the farm economy. As a result, small businesses, entrepreneurs, agribusinesses, and farmers are connecting with education and resources so they can remain financially solvent, find alternate markets, and increase their profitability.
- 7 counties are supporting Iowans in improving financial security. Individuals and families are learning how to prioritize bills, protect credit, and manage debt.
- 12 counties are engaging Iowans in improving food supply, safety, and access. These efforts address local needs including nutrition education, donation gardens, farmers markets, and food system coalitions.
- 17 counties are expanding educational opportunities for youth with programs that spark youth interest, support academics, and promote youth resiliency.
- 8 counties are supporting efforts for increasing access to quality child care by networking with community partners and connecting providers with education.
- 30 counties are engaging Iowans in addressing mental health and providing access to research-based training and education on mental health literacy and suicide prevention.

These county-level efforts created or strengthened over 200 partnerships and coalitions and reached 30,499 Iowans. (As reported by counties in December 2021. Counties may have reported on more than one initiative.)

## Stakeholder Input

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

None

### Methods to identify individuals and groups and brief explanation

None

### Methods for collecting stakeholder input and brief explanation

None

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

None


## Highlighted Results by Project or Program


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Critical Issue

### Community and Economic Development

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<i>Program</i>			
<a href="#">Iowa Farmland Leasing Education Program</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>
	1	Iowa State University	Keli Tallman 

<i>Program</i>			
<a href="#">Municipal Professionals Academy</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>
	1	Iowa State University	Keli Tallman 



<i>Project</i>				
<a href="#">Social, Economic and Environmental Causes and Consequences of Demographic Change in Rural America</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	▼
	1	Iowa State University	David Peters	

<i>Project</i>				
<a href="#">Sociological Research to Advance Sustainable U.S. and International Food Security and Rural Development</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	▼
	1	Iowa State University	J Arbuckle	

<i>Program</i>				
<a href="#">Women in Agriculture</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	▼
	1	Iowa State University	Keli Tallman	

Critical Issue

[Food Production and Agricultural Systems](#)

<i>Project</i>				
<a href="#">Advanced Technologies for the Genetic Improvement of Poultry</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	▼
	1	Iowa State University	Susan Lamont	

<i>Program</i>				
<a href="#">Beef Quality Assurance Education</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	▼
	1	Iowa State University	Keli Tallman	

<i>Project</i>				
<a href="#">Enhancing Microbial Food Safety by Risk Analysis</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	▼
	1	Iowa State University	James Dickson	

<i>Project</i>				
<a href="#">Improving Soybean Arthropod Pest</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	▼
	1	Iowa State	Matthew O`Neal	

[Management in the U.S.](#)

University

*Project*

[Interaction of cropping systems with their environment in the central United States](#)

**Results**

1

**Organization**

Iowa State University

**Project Director**

Andy VanLoocke



*Program*

[Iowa Farm to School and Early Care Program](#)

**Results**

1

**Organization**

Iowa State University

**Project Director**

Keli Tallman



*Project*

[Predicting Genotype by Management by Environment Interactions across Scales](#)

**Results**

1

**Organization**

Iowa State University

**Project Director**

Sotirios Archontoulis



*Program*

[Produce Safety Alliance Trainings Show Knowledge Gain](#)

**Results**

1

**Organization**

Iowa State University

**Project Director**

Keli Tallman



*Project*

[Remote Sensing of Soil Moisture and Crop Water to Facilitate Improved Forecasts of Weather and Climate in the Corn Belt of the Midwest United States](#)

**Results**

1

**Organization**

Iowa State University

**Project Director**

Brian Hornbuckle



*Program*

[Soil Fertility Workshops Improve Profitability, Reduce Environmental Impact](#)

**Results**

1

**Organization**

Iowa State University

**Project Director**

Keli Tallman



Critical Issue

## Health, Nutrition and Well-being

<i>Project</i> <a href="#">Biology, Ecology &amp; Management of Emerging Disease Vectors</a>	<b>Results</b> 1	<b>Organization</b> Iowa State University	<b>Project Director</b> Ryan Smith	▼
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<i>Program</i> <a href="#">EFNEP and SNAP-Ed Nutrition Education and Healthy Food Access Programs</a>	<b>Results</b> 1	<b>Organization</b> Iowa State University	<b>Project Director</b> Keli Tallman	▼
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<i>Project</i> <a href="#">Improving Human Foods: Functionality, Selection, and Nutrition</a>	<b>Results</b> 1	<b>Organization</b> Iowa State University	<b>Project Director</b> James Hollis	▼
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<i>Project</i> <a href="#">Nutrient Bioavailability-- Phytonutrients and Beyond</a>	<b>Results</b> 1	<b>Organization</b> Iowa State University	<b>Project Director</b> Wendy White	▼
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<i>Project</i> <a href="#">Personal Protective Technologies for Current and Emerging Occupational and Environmental Hazards</a>	<b>Results</b> 1	<b>Organization</b> Iowa State University	<b>Project Director</b> Chunhui Xiang	▼
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<i>Program</i> <a href="#">Servsafe® Food Protection Manager Certification</a>	<b>Results</b> 1	<b>Organization</b> Iowa State University	<b>Project Director</b> Keli Tallman	▼
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Critical Issue

## Human Potential and Youth Development

<i>Program</i>				
<a href="#">Essentials to Child Care</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	
	1	Iowa State University	Keli Tallman	▼

<i>Program</i>				
<a href="#">Iowa Mental Health Education Program</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	
	1	Iowa State University	Keli Tallman	▼

<i>Program</i>				
<a href="#">Mindful Teen</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	
	1	Iowa State University	Keli Tallman	▼

<i>Program</i>				
<a href="#">Volunteer Income Tax Assistance (VITA)</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	
	1	Iowa State University	Keli Tallman	▼

Critical Issue

### [Natural Resources and Environmental Stewardship](#)

<i>Project</i>				
<a href="#">Investigations into Aquatic Resources Biology, Ecology and Management</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	
	2	Iowa State University	Joseph Morris	▼

<i>Program</i>				
<a href="#">Iowa Master Conservationist Program</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	
	1	Iowa State University	Keli Tallman	▼

<i>Program</i>				
<a href="#">Iowa Watershed Academy</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	
	1	Iowa State University	Keli Tallman	▼

<i>Project</i>				
<a href="#">MONARCH BUTTERFLY CONSERVATION</a>	<b>Results</b>	<b>Organization</b>	<b>Project Director</b>	
	1	Iowa State University	Steven Bradbury	▼

<i>Project</i>				
<a href="#">Soil, Water, and Environmental Physics to</a>				

<a href="#">Sustain Agriculture and Natural Resources</a>	<b>Results</b> 1	<b>Organization</b> Iowa State University	<b>Project Director</b> Robert Horton	▼
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*Project*

<a href="#">Sustainable Solutions to Problems Affecting Bee Health</a>	<b>Results</b> 1	<b>Organization</b> Iowa State University	<b>Project Director</b> Amy Toth	▼
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Critical Issue

### [Transformative Technology](#)

*Project*

<a href="#">Agricultural machinery and technology development for advancing agricultural productivity and sustainability</a>	<b>Results</b> 1	<b>Organization</b> Iowa State University	<b>Project Director</b> Brian Steward	▼
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*Project*

<a href="#">Integrated Systems Research and Development in Automation and Sensors for Sustainability of Specialty Crops</a>	<b>Results</b> 1	<b>Organization</b> Iowa State University	<b>Project Director</b> Lie Tang	▼
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*Project*

<a href="#">National Animal Genome Research Program</a>	<b>Results</b> 1	<b>Organization</b> Iowa State University	<b>Project Director</b> Christopher Tuggle	▼
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### Appendix

Research Projects



Extension Programs



Other Projects / Programs



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## Report Actions

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RETRACT