

FY 2020 Annual Report of Accomplishments and Results

Iowa

Iowa State University

I. Report Overview

The NIFA reviewer will refer to the executive summary submitted in your FY 2020 Plan of Work located in the Institutional Profile. Use this space to provide updates if needed.

1. Executive Summary (Optional)

See FY 2020 Plan of Work.

II. Merit and Scientific Peer Review Processes

The NIFA reviewer will refer to your 2020 Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Process	Updates ONLY
1. The <u>Merit Review Process</u>	
2. The <u>Scientific Peer Review Process</u>	

III. Stakeholder Input

The NIFA reviewer will refer to your 2020 Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Stakeholder Input Aspects	Updates ONLY
1. Actions taken to seek stakeholder input that encouraged their participation with a brief explanation	
2. Methods to identify individuals and groups and brief explanation.	
3. Methods for collecting stakeholder input and brief explanation.	
4. A Statement of how the input will be considered and brief explanation of what you learned from your stakeholders.	

IV. Critical Issues Table of Contents

No.	Critical Issues in order of appearance in Table V. Activities and Accomplishments
1.	Community and Economic Development
2.	Food Production and Agricultural Systems
3.	Health, Nutrition, and Well-Being
4.	Human Potential and Youth Development
5.	Natural Resources and Environmental Stewardship
6.	Transformative Technology

V. Activities and Accomplishments

Please provide information for activities that represent the best work of your institution(s). In your outcome or impact statement, please include the following elements (in any order): 1) the issue and its significance (e.g. who cares and why); 2) a brief description of key activities undertaken to achieve the goals and objectives; 3) changes in knowledge, behavior, or condition resulting from the project or program’s activities; 4) who benefited and how. Please weave supporting data into the narrative.

No.	Project or Program Title	Outcome/Impact Statement	Critical Issue Name or No.
1.	Iowa Municipal Professionals Institute and Academy	<p>Issue:</p> <p>The Iowa Municipal Professionals Institute and Academy (Iowa MPI/A) began almost 50 years ago to address high employee turnover in Iowa communities, particularly rural communities. According to the Iowa MPI/A, low retention rates result in a loss of knowledge of laws/codes to successfully operate municipalities. Without MPI/A, communities were at risk of inaccurate reporting, audit failures, legal troubles, etc. MPI/A was created to bridge that gap and ensure the highest quality of instruction and education, regardless of staffing limitations. IMFOA (Iowa Municipal Finance Officers Association) research shows that when municipal staff attend MPI/A, it significantly impacts the individual’s knowledge base that is directly applied in their communities. Municipalities in Iowa were seeing higher accuracy and efficiency in city and</p>	Community and Economic Development

		<p>municipality administration. Criteria for education at MPI/A required live and in-person instruction. In 2020, MPI/A was at risk of not being held due to the pandemic.</p> <p>Response: Requests came throughout the state for MPI/A to still be held. Municipal staff, administration and elected officials could not conduct their jobs efficiently without receiving applicable and vital training. Approval was sought from CED Institute and Academy Director Sara Shonrock to move MPI/A 100% virtual. Shonrock was required to get authorization from IIMC (International Institute of Municipal Clerks) and IMFOA (Iowa Municipal Finance Officers Association) to move the learning formats online and was faced with stringent guidelines from both organizations to maintain the credibility of the content delivered, attendee interaction and results. It is important to note, if any of the 44 courses offered did not follow set guidelines, participants would not receive credit for the course. In 2020, 44 courses were offered online. The courses covered content such as administrative law, intergovernmental relations, writing resolutions and ordinances, and public funds investing. 300 participants engaged in the 44 online courses. The 300 participants were from all 99 Iowa counties and represented positions such as city clerk, city administrator and finance directors.</p> <p>Results: Of the 300 unique participants who registered for the courses, 35 of these participants were able to complete their Municipal Clerk/Finance Officer Certification (or Master’s Certification). 45% (16 participants) of the 35 certified individuals received a pay raise from their employer due to earning their certification.</p>	
<p>2.</p>	<p>Expanding Businesses through the DreamBuilder Program</p>	<p>Issue: While there are many programs throughout the state that address small business start-ups, the need also existed for a business retention and expansion program. In Lee County, business owners and entrepreneurs were facing a stagnant local economy. Owners and entrepreneurs had ideas for expansion as well as new businesses, but no resources to move their ideas forward.</p>	<p>Community and Economic Development</p>

		<p>Response: The Keokuk and Fort Madison Area Chambers of Commerce, along with America’s Small Business Development Centers of Iowa (SBDC) and CED Field Specialist Shelley Oltmans, developed the DreamBuilder cohort program as a direct response to the requests for more resources for business owners/entrepreneurs. An online training program that helps create business plans, new skills for marketing and expansion, and creating a small-business support network, DreamBuilder provided an educational training opportunity to help entrepreneurs gain these new skillsets, create and pitch business plans, and increase their access and understanding of funding options (PenCity Current, 2020). In 2020, 12 participants attended the DreamBuilder program. The program fee is \$125 per participant (refundable upon completion of online course and submission of a business plan). The participants were from 3 Iowa counties, 1 Illinois county and represented existing and potential business owners/entrepreneurs. Participants engaged in weekly classes and practicums over a 4-month timeframe. In total, the 12 participants represented 7 existing businesses and 4 business models.</p> <p>Results: 2020 marked the initial year of the facilitation of the DreamBuilder Program and it was deemed a success. 12 participants engaged in the program; two participants were from underserved populations. Five (42%) of the 12 participants, representing four different types of businesses, participated in a pitch contest with five local bankers. In total, \$6,000 was donated by the five local banks and two economic development organizations as seed funds for the four newly proposed business expansion plans. 33% of the attending business owners (4) have expanded their business as a direct result of their participation in DreamBuilder. Three businesses expanded their clientele. Furthermore, one business owner doubled their in-home business revenue and is now actively seeking a commercial business site. A camper-rental business doubled their available fleet of campers.</p>	
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<p>3.</p>	<p>Central Iowa Ag Marketing Clubs Assist Farmers in Increasing Their Net Farm Income</p>	<p>Issue: Iowa net farm income on an accrual basis dropped by nearly 41% from 2014 to 2018. This decline was despite above average crop yields and improved livestock production efficiencies. Farmers face ever-increasing challenges of global commodity production that competes with US ag exports. The US-China Trade War lasted 18 months and damaged crop and livestock demand and prices.</p> <p>Response: Since 2000, ISU Extension and Outreach in Central Iowa established three successful ag marketing clubs and added an online learning resource beginning in 2010, called the Iowa Commodity Challenge (https://www.extension.iastate.edu/agdm/info/icc.html). The webpage was developed in partnership with the Iowa Farm Bureau and includes weekly updates, 15 educational videos, a marketing tools workbook, market planning worksheets, and basic tracking tables that are updated weekly. County extension offices promoted and coordinated monthly ag marketing club meetings during the late fall and winter months. A farm management specialist and guest speakers facilitate face-to-face presentations. 338 participants engaged in the program from March 2019 – March 2020. Many of these same individuals accessed resources on the Iowa Commodity Challenge webpage.</p> <p>Results: Those attending the March 2020 Central Iowa ag marketing club meetings were invited to respond to a written survey. This survey measured the impact these educational efforts had on the marketing of their 2019 corn and soybean crops. Survey responses were obtained from 110 club participants to evaluate the effectiveness of these educational efforts. Survey respondents indicated that their net farm income resulting from these educational efforts in crop price risk management increased by an average of \$15,837 per farm operation. The average farm size of their combined corn and soybean production was 749 tillable acres. Thus, the impact of this educational program was \$21.13 per tillable acre and more than \$1,742,000 for all respondents. In addition, at</p>	<p>Community and Economic Development</p>
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		<p>Southwest Iowa marketing clubs, 23 respondents reported the average value of the program to their farm operation was \$17.15 per acre. The average acres farmed were 678, for a total of \$267,000 in Southwest Iowa and a program total benefit of more than \$2,000,000.</p>	
<p>4.</p>	<p>Written Land Rental Leases Making an Impact in Iowa</p>	<p>Issue: 58% of Iowa farmland is owned by someone who does not currently farm. 34% are owners with no farming experience and the remaining 24% are owned by retired farmers (2017 Farmland Ownership and Tenure Survey.) In today’s rental market, approximately 30%-40% of crop revenue goes toward farm rental expenses (Table 1, www. https://www.extension.iastate.edu/agdm/wholefarm/html/c2-20.html). Leasing arrangements are a top concern for Iowa producers and the owners of Iowa farmland. Rental rates peaked in 2013 at \$270/acre, and while values have shown slight declines the last few years, they still have not returned to levels seen prior to the increase in commodity prices. Personal finance pressures on an aging landowner population that rely on rental income for their livelihood put added pressure on lease negotiations.</p> <p>Response: The Farmland Ownership and Tenure Survey is conducted every five years by Iowa State University researchers and extension economists. Results are shared with farmers and others through extension publications, and meetings. In 2019, 86 extension leasing meetings were held during July-August, reaching 1,444 individuals. These meetings are a regular event for many of the attendees with 65% having attended programs in a previous year. The majority of the attendees are non-farming landowners (63%) followed by active farmers (20%) and a mix of ag professionals such as ag lenders, attorneys, accountants, and farm managers. Other attendees are often relatives or a non-farming landowner who help in decisions or someone who anticipates inheriting land or renting out land in the near future.</p> <p>Results:</p>	<p>Community and Economic Development</p>

		<p>Of the 1,444 participants, 664 provided a valid email address to receive a post-program evaluation, with 293 responding (44%). Through these programs, an invitation is given to also join the Iowa cash rental rate survey done each spring. As a result of this request, approximately 231 names were added to the 2020 cash rental rate survey. 83% of survey respondents (211) are using written leases in their leasing arrangements. Of those responding to the survey, 44 were not using a written lease. When asked what changes would be made the next year, 22 of the 44 participants (50%) were going to move to using written leases. Having a written agreement has been encouraged for several years during the leasing program and the number using only an oral agreement continues to decline, improving the records and relationships in leasing arrangements for all parties involved and reducing chances of misunderstanding or conflict during the lease period. On average, participants influence 772 acres each. Applied to the 1,425 participants, this is 1.1 million acres of rented farmland in the state, and at the average rental rate of \$219/acre in 2019, \$242 million in revenue is affected by this program.</p>	
<p>5.</p>	<p>Addressing the challenges of business ownership for underserved populations in Iowa’s small and rural communities</p>	<p>Issue: A thriving rural community includes food- and fiber-related small businesses across the supply chain, from agricultural producers (e.g., dairy goat or alpaca farmers), to small manufacturers of value-added products (e.g., cottage foods producers, microbreweries, t-shirt printers), and ending with retail/consumer experiences (e.g., agritourism events, wineries, local restaurants, and quilt shops). This array of food- and fiber-related small businesses provides livelihoods for their owners and employees, desired amenities for a community of residence, and a "sense of place" that attracts tourists to rural communities. The economic recession of 2007-2009, and business challenges since then, has 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), particularly for two sizeable but underserved Iowa populations: women and older residents ages 50+.</p> <p>Response:</p>	<p>Community and Economic Development</p>

		<p>Environmental factors of success examined in research during the past year include education, new retail formats, motivations of direct seller, and company support for direct sellers. Better trend forecasting was identified as contributing to the success of women's start-ups across a range of business types and for fiber-related, fashion-based businesses in particular. New retail formats may also contribute to the success of start-ups, particularly for fashion-related businesses. Slaton et al.'s (2020) findings introduced a retail format alternative -- small, inventory-free stores -- that may allow more women to own retail operations and do so with fewer financial constraints, because of the smaller up-front investment required for inventory-free stores. This store format was found to be successful at building brand equity and fostering purchase intentions, which may help ensure business success as well. More than 75 people attended the presentation of this research at the International Textiles and Apparel Association conference (Oct. 2019).</p> <p>Results: Knowledge of environmental factors of success, enhances the entrepreneurial potential of our target populations and assists their advisors.</p>	
<p>6.</p>	<p>Reducing Calf Deaths During Calving Improves Beef Industry</p>	<p>Issue: According to the 2015 NAHMS report, the U.S. cattle herd lost 5.5% of all beef calves born. Calf death loss cost the industry \$668 million in 2015; \$41 million in Iowa alone. Iowa loses 9.6% of the calf crop to non-predator causes. Nationally, 9% of cow deaths and 17.8% of calf deaths are related to calving problems, and in Iowa 20% of calf deaths are due to calving related issues. Cow and calf death loss is higher for small herds (<49 cows) than in larger herds. In small herds, 17.8% of cattle deaths are due to calving related problems.</p> <p>Reducing cow and calf deaths due to calving difficulties improves the welfare of cattle and increases cow herd income and profitability. By properly managing heifers and cows and the risk associated with birth and the first few weeks of life, producers can increase the percentage of calves that survive to weaning.</p>	<p>Food Production and Agricultural Systems</p>

		<p>Response: Nine calving clinics were held in Iowa in 2018, 2019 and 2020 by Iowa Beef Center Extension Specialists. Topics included cow nutrition, neonatal calf health and care, hands-on sessions on normal calving and dystocia, and first aid. Overall, 353 producers attended the clinics which also included producers from Minnesota and Illinois.</p> <p>Results: In August 2020, a survey was sent to 240 participants who attended a calving clinic in the last 3 years. Sixty-nine completed surveys were returned (27% response rate). Participants were asked to identify their knowledge increase on a scale of 1 (low) to 5 (high). The average increase in knowledge was 3.5 to 4.0 with more than half of the respondents indicating an increase of 4 or 5. More than half also reported making at least 1 management change. Management changes included better preparation for calving, ensuring adequate colostrum intake, and improving cow nutrition. Of the respondents that returned the survey, 58.3% reported that attending the program helped them save at least one calf during calving or the neonatal time period with an average of 0.9 calves saved per attendee. Participants are better prepared to handle difficult dystocia situations and calf first aid resulting in decreased death loss, improved calving percentage and increased profits. Respondents indicated an average benefit of attending the program of \$7.56 per cow, which correlates to \$1,333 per operation. Based on total number of attendees at all of the calving clinic programs this translates to \$375,906 benefit to the Iowa cattle industry and economy.</p>	
7.	<p>Ag Lenders Seminars Assist in Effectively Evaluating Dairy Enterprise Profitability</p>	<p>Issue: Dairies in the six upper Midwest states represent nearly 2.5 million cows and over 50 billion pounds of milk produced annually. In Iowa, nearly 1,000 dairies milk over 219,000 cows every day. Studies indicate farm operations have lost up to \$2.5 billion in working capital over the past five years. Armed with the most recent data and research, lenders can help provide finances to strengthen this industry.</p> <p>Response:</p>	<p>Food Production and Agricultural Systems</p>

		<p>The Tri-State and Siouxland Ag Lenders Seminars were combined into a single virtual seminar in early November due to COVID-19 health concerns. Participants included 158 lenders, consultants, and academics from five upper mid-west states that influence 7,033 ag producers that farm more than 4.8 million acres and milk over 381,767 dairy cows. Participants heard four presenters that focused on dairy and agricultural market outlooks; economic returns on milking robots; Farm Bill considerations; farm financial accounting and record keeping; and barn safety, fire prevention, and insurance. Research-based information learned is used by participants in annual client reviews and other financial consulting.</p> <p>Results We asked lenders to estimate the economic benefit on a per client basis as a direct result of what they learned at this program. In 2020 the aggregate benefit was over \$109,000. The multiplier effect of participants sharing the information they learned from an extension educational program with others is important to note. To determine that number, we asked how many participants planned to share seminar information with others. From their responses, we anticipate an additional 3,140 people will receive seminar information from this program. Concerning the overall satisfaction with the program, 94% indicated they were completely or mostly satisfied.</p>	
<p>8.</p>	<p>Iowa Farm to School and Early Care Coalition Bring Local Produce to School Districts’ Meal Programs</p>	<p>Issue: Research shows that when children are well-nourished, they learn better. The USDA recommends a minimum of .5 - 1 cup per day of fruits, and .75 – 1 cup per day of vegetables for each child, depending upon age. Increasing the amount of fruits and vegetables Iowa’s schools purchase from local farmers will increase freshness and nutrition content for Iowa children and market opportunities and profitability for Iowa farmers. Increasing farm to school activities for Iowa’s K-12 schools and early care sites is a win for students, teachers, farmers, and communities.</p> <p>Response:</p>	<p>Food Production and Agricultural Systems</p>

		<p>Currently comprised of more than 20 organizations, the Iowa Farm to School and Early Care Coalition formed in early 2020 through the merger of the Iowa Farm to School Coalition and the Iowa Farm to ECE Coalition. Members meet bi-monthly for half-day meetings, and smaller strategy teams meet once per month to work on specific goals. Three ISU Extension and Outreach Farm, Food, and Enterprise Development team members represent Iowa State in the coalition; a farm to school program coordinator, an evaluation coordinator, and a field specialist.</p> <p>Results: The coalition’s first annual report, released this fall, includes the following impacts for the 2019-20 program year. More than 200,000 youth at more than 1,000 schools and early care sites participated in farm to school and EC activities. 390 districts and early care sites procured local food for their meal programs. 107,900 meals featuring locally sourced foods were served on Iowa Local Food Day 2019 (and more than 59,000 in 2020 despite the pandemic). Schools and early care sites reported purchases of more than \$500,000 in local foods. Iowa F2S and EC programs won more than \$375,000 in grant funds for their work.</p>	
<p>9.</p>	<p>Extracting more useful information from data, for agricultural studies</p>	<p>Issue: Collecting and analyzing data are important components of most experiment station research projects. Often these require new statistical methods, evaluation of methods in novel settings, and sharing the use and interpretation of statistical methods. In all cases, our project goal is to extract more useful information from data. Here we give one example of the many methods we developed this project period.</p> <p>Response: Accurate genotyping of crop species is critical for breeding efforts, but next generation sequencing data often contains errors. We developed a novel statistical method and accompanying software to identify true genetic variants in error-prone sequence data sampled from complex biological populations. The most common application is to microbiome studies that evaluate how a microbial population responds to perturbation.</p>	<p>Food Production and Agricultural Systems</p>

		<p>They showed that their method is better able to distinguish true variants from error variants.</p> <p>Results: Methods like this underlie studies on the effect of antibiotics on animal agriculture, and the effect of animal agriculture on the environment. Good study design and data analysis are the foundation for scientific progress.</p>	
<p>10.</p>	<p>Management of western corn rootworm and other insect pests of corn</p>	<p>Issue: Each year, US farmers suffer billions of dollars in economic losses due to insect pests of corn, with these losses arising as a result of both management costs and lost yield. One of the most serious pests of corn in the US Corn Belt is the western corn rootworm. The challenges associated with management of western corn rootworm have increased over time due to the evolution of resistance to various management practices including crop rotation, conventional insecticides, and corn that produces insecticidal proteins derived from the bacterium <i>Bacillus thuringiensis</i> (Bt).</p> <p>Response: As part of this project, extensive research has been conducted on resistance to Bt corn by western corn rootworm, using both laboratory-selected strains and strains with field-evolved resistance. Research on Bt resistance has included monitoring field populations for the development of resistance, and measuring features associated with resistance, specifically the inheritance of resistance and the extent to which resistance has accompanying fitness costs. These data have enabled scientists and regulators to better understand the spread and persistence of resistance in the landscape, and to improve the long-term viability of Bt corn as a management tool for rootworm.</p> <p>Results: Research, publications and presentations, conducted as part of this project, have provided farmers with timely information on the effectiveness of current management tools for corn rootworm and other insect pests of corn; policy makers and biotechnology</p>	<p>Food Production and Agricultural Systems</p>

		<p>companies with data on the long-term durability of Bt technologies for management of corn rootworm; and scientists with new information on interactions between corn and one of its associated agricultural pests.</p>	
<p>11.</p>	<p>Transposition and Expansion of the Maize Functional Genome</p>	<p>Issue: Maize is the most important crop plant in the USA, and much of the success of maize stems from its genetic diversity which enables plant breeders to develop varieties that are successful across a wide spectrum of environments. Although genetic and genomic diversity in maize is widespread, the mechanisms that generate this diversity are largely unknown. Gene duplications and genome rearrangements are common in plants, and are widely recognized as fundamentally important in genome evolution. Duplications not only can increase expression of the affected genes, they provide genetic redundancy to facilitate divergence and sub-functionalization, thereby allowing for increased diversity and complexity.</p> <p>Response: We investigated the role of transposable elements, or jumping genes, in generating duplications and other genome rearrangements. We identified Alternative Transposition as a new mechanism by which certain chromosomal segments duplicate and rearrange functional segments, ranging from individual genic elements and whole genes, up to large duplications containing hundreds of genes. This project provided training for two graduate students in classical and molecular genetic approaches, as well as computational methods. The project also provided research experience and on-the-job training for two undergraduate students.</p> <p>Results: Once the mechanism by which transposable elements induce genome rearrangements is known, it may be possible to use this mechanism to generate diversity; for example, by making duplications of beneficial genes, or by deleting harmful genes. Also, the results will provide new insight into the forces that continue to shape plant genomes and may provide insight into how plant species may respond and adapt to climate change. The</p>	<p>Food Production and Agricultural Systems</p>

		educational activities of this project provided training and experience that is otherwise unavailable to young students and future scientists, and will thereby help to enhance the potential for scientific and technological research in the USA.	
12.	Environmental persistence and virulence of Listeria monocytogenes	<p>Issue: The foodborne pathogen Listeria monocytogenes is responsible for listeriosis, a rare but severe disease in humans, which is acquired primarily through the consumption of contaminated food; particularly "ready-to-eat food" is of high risk. Persistence of L. monocytogenes in food production environments is often observed and thus a big challenge for food safety in many areas of food production. A better understanding of these molecular mechanisms is thus urgently needed to increase food safety and to be able to develop better control mechanisms against L. monocytogenes in the long-term.</p> <p>Response: We performed the first large-scale survey of plasmids in Listeria monocytogenes. We showed that non-coding RNAs both on the chromosome and the plasmids may be crucial for L. monocytogenes stress survival.</p> <p>Results: The results of our research this period provided a better understanding of the contribution and genetics of L. monocytogenes chromosomal and plasmid genes to survival in food production environments. This increased knowledge may provide a better knowledge basis for risk assessment of L. monocytogenes occurrence in food and food processing environments in the future.</p>	Food Production and Agricultural Systems
13.	Practical Management of Nematodes on Corn, Soybeans and Other Crops of Regional Importance	<p>Issue: Plant-parasitic nematodes (PPNs) infect a variety of economically important crops like rice, wheat, maize, soybean, potato, tomato, and sugar beet. PPNs are one of the major constraints to crop production, and especially in high-value vegetable and fruit crops, they can cause significant economic yield loss, estimated to be more than US\$100 billion annually (Bernard et al., 2017). PPNs are a major constraint to agricultural production across the North Central Region.</p>	Food Production and Agricultural Systems

		<p>Response: Soybean varieties described as resistant to the soybean cyst nematode (SCN) were evaluated in nine field experiments throughout Iowa to assess the agronomic performance of the varieties as well as their effect on population densities of the nematode. In 2019, a total of 207 SCN-resistant soybean varieties were studied. A list of SCN-resistant soybean varieties available to Iowa growers was compiled in November 2019. The list was created as an Iowa State University Extension publication and made available free of charge on the Internet in PDF format. The 2019 list contained information on 891 soybean varieties in maturity groups 0, 1, 2, and 3. Results of our experiments were also shared with other Midwestern states during our activities within the NC1197 multi-state project.</p> <p>Results: Results of our field experiments illustrated the benefits of using nematode-protectant seed treatments, allowing farmers and crop advisors to decide whether the likelihood of gaining benefits from the products is greater than the costs of the products. Also, the research showed which SCN-resistant soybean varieties provide good SCN control and high yields in order to help farmers select soybean varieties to grow in fields infested with the nematode to maximize yields and minimize increases in nematode population densities.</p>	
14.	<p>ServSafe® Certification Aims to Reduce Foodborne Illness</p>	<p>Issue: It is estimated that 48 million people experience a foodborne illness each year with 3,000 deaths resulting from these illnesses. Providing food handlers and decision makers involved in food preparation and service with knowledge about risks can help in reducing incidents of foodborne illness by leading to better practices.</p> <p>Response:</p>	<p>Health, Nutrition, and Well-Being</p>

		<p>The COVID-19 pandemic significantly affected how ServSafe® was offered throughout Iowa. For three months beginning March 2020, classes were not offered face-to-face. When resumed, the program was offered with limited number of participants to ensure adequate social distance for safety of staff and participants. More than 1,600 Iowans participated in an 8-hour workshop about safe food handling practices.</p> <p>Results: Of Iowans who participated in the 8-hour certification course workshop, 79% (n = 1,298) were successful in earning certification as Certified Food Protection Managers.</p>	
15.	Iowans Learn Safe Home Food Preservation Techniques	<p>Issue: Interest in home food preservation has steadily increased due to the local food movement and economy. According to the National Center on Home Food Preservation, 1 in 5 U.S. households can their own food; however, many are unaware of the food safety issues that home food preservation encompasses. Interest increased further in response to the COVID-19 pandemic.</p> <p>Response: 3,043 Iowans received food preservation assistance. Of these, 131 adults and 70 youth participated in food preservation education programming. Of these 131 adults, 10 took a hands-on workshop and 121 attended a general food preservation class. Additionally, 2,842 individuals called in for technical assistance with food preservation questions.</p> <p>Results: Of those who took part in the online food preservation lessons, all (100% (n = 121) reported an increase in “high to very high” post knowledge about canning processing times, foodborne illness (e.g. causes, high risk foods), safe food handling practices, and recommended canning practices.</p>	Health, Nutrition, and Well-Being
16.	Addressing Iowa’s Food Insecurity through Food Pantry Donations	<p>Issue: 12% of Iowa's population is food insecure. The US Department of Agriculture (USDA) defines food insecurity as a lack of consistent access to enough food for an active,</p>	Health, Nutrition, and Well-Being

		<p>healthy life. Compared with people in food-secure households, people in food-insecure households are more likely to report poorer health and have a higher risk for diet-related chronic conditions such as obesity, hypertension, and diabetes (Cheyne et. al., 2020). One in seven Iowans visits a food pantry at least once in any given year. The type and variety of food available through the food pantry system is important for many Iowans’ nutritional status.</p> <p>Response: Iowa State University SNAP-Ed and Master Gardener programs have created a collaborative project to improve access to fruits and vegetables in Iowa's food pantries. Master Gardeners across the state received training on working with food pantries and food safety in donation gardens. They were provided with an opportunity to receive mini grants to fund donation gardens in partnership with their local food pantries. Additionally, ISU Extension and Outreach’s SNAP-Ed program partners with Grow Johnson County and Table to Table Food Rescue to increase access to fruits and vegetables in food pantries in Southeast Iowa. These healthy food access projects continued throughout the pandemic with additional safety precautions and adjusted delivery processes to suit changing pantry distribution practices.</p> <p>Results: In 2020, 229 Master Gardener volunteers participated during the fifth year of the project. Master Gardeners raised and donated 81,000 pounds of fruits and vegetables for their partner pantries. The partnership with Table to Table led to 220,160 pounds of fruits and vegetables distributed through food pantries. In total, the project yielded 301,160 pounds of fruits and vegetables for Iowa food pantry clients equating to 903,480 servings.</p>	
<p>17.</p>	<p>Improving Human Foods: Functionality, Selection, and Nutrition</p>	<p>Issue: The probiotic yogurt market is strong not only because of appealing flavor and textural properties, but also because of the potential health benefits that probiotics provide. However, probiotic viability can be easily affected by the environment. Edible bigels,</p>	<p>Health, Nutrition, and Well-Being</p>

		<p>recently-developed soft materials, have shown effectiveness in delivering bioactive components to humans. However, applied research of bigel in food is lacking.</p> <p>Response: We studied the use of bigel technology to improve the survival of probiotics in yogurt and evaluated the physical and rheological properties of yogurt after addition of bigel. Food rheological properties can be used to predict the following: (1) the processability of food materials in the manufacturing pipeline, (2) the stability of manufactured liquid and semisolid food products under different storage conditions, (3) the sensory texture and mouthfeel attributes of processed foods, and (4) the ability of food components to be digested and absorbed in the human gastrointestinal tract. A couple of our many findings are: The total counts of <i>L. acidophilus</i> and <i>B. lactis</i> entrapped in bigels were significantly higher than free bacteria in yogurt after three weeks and five weeks, respectively, which indicated probiotics could be effectively entrapped, and their survival enhanced, in bigel systems. The presence of phospholipids and whey protein in the bigel matrix enhanced probiotic survival. No significant difference in probiotics survival was found between yogurt styles, which indicated that the bigel macrostructure structure might not play a key role in protecting the probiotic viability in yogurt, but nano- and microstructure likely do.</p> <p>Results: This research has laid the groundwork for using bigel in foods. Additional work may need to be done to optimize bigel structure for other applications, but this work has shown how bigels are assembled, how their phases interact, and their ability to protect probiotics during in vitro digestion.</p>	
18.	4-H STEM Learning Experiences for All Youth	<p>Issue: STEM (science, technology, engineering, and mathematics) researchers have documented an increasing and persistent inequity in both youth achievement and participation (Morgan, Farkas, Hillemeir, & Maczuga, 2016). Without access to STEM learning opportunities, youth may enter the professional world ill-prepared to fully</p>	Human Potential and Youth Development

		<p>participate in a modern society that values innovation, creativity, and problem solving (After School Alliance Executive Summary, 2015; Mishra & Mehta; 2017). One way to address these inequities is to focus on creating and increasing access to high quality, inclusive informal STEM learning experiences for all youth.</p> <p>Response: Nearly 54,000 Iowa 4-H members chose Science, Technology, Engineering, or Math (STEM) as their project area learning. New initiatives for 2020 included further integration with the Women in Science and Engineering program at ISU; work with the NASA Iowa Space Grant to create Astro Camp, and a completely virtual State Science and Technology Fair, serving 122 youth. Iowa 4-H has created a new website to feature all available STEM programs - https://www.extension.iastate.edu/4h/stem</p> <p>Results: Using National 4-H Council’s 4-H Common Measures 2.0, 70 youth, or 27% of program participants (260 total youth), reported on STEM constructs of science interest and thinking, science skills and attitudes, and engineering skills and attitudes. The responses are generally “Yes”, “Maybe”, and “No.” “Yes”, “Usually”, “No”, or “Yes,” “Usually,” “Not Really” and “No.” The indicators are scored 4 for Yes down to 1 for No. Youth were between the ages of 11 and 19. 39% were female and 16% were male. For STEM processing, 64% reported asking questions to see how things work; 67% said they try new things to see how they will work; 51% said they compare how different things work; and 83% said they shared a science-related project because of 4-H.</p>	
<p>19.</p>	<p>4-H Supports College and Career Readiness for First-Generation College Students</p>	<p>Issue: At ISU, 20% of undergraduates are first-generation college students. Historically, Iowa 4-H members show a high regard for post-secondary education or trade school. In 2020, of the 985 graduating 4-H seniors, 83% (818) reported they plan to attend college or trade school. Across the state, Iowa 4-H plays a key role in preparing youth for careers and post-secondary education. Via the 4-H Connect Program, Iowa 4-H works to expose more Iowa youth to college and careers for those who do not have a family</p>	<p>Human Potential and Youth Development</p>

		<p>history of college attendance. Iowa 4-H Connect has been expanded beyond Iowa State University to other college campuses. College campus partners include Buena Vista University, Northwestern College, Simpson College, Des Moines Area Community College, and Southwest Iowa Community College.</p> <p>Response: The Iowa 4-H Program strongly emphasizes college and career opportunities, readiness, and paths within 4-H learning experiences; please see https://www.extension.iastate.edu/news/iowa-4-h-resources-encourage-young-people-explore-career-paths-college. Youth who completed 4-H Common Measures 2.0 evaluations engaged in either the Iowa 4-H State Recognition process, where youth had the opportunity to apply and be interviewed by an adult panel for selection in statewide 4-H leadership positions and project area awards or engaged in AgOvation, where youth teams develop products to address real-life agricultural challenges.</p> <p>Results: Of the 300 youth program participants in grades 8th – 12th who completed the 4-H Common Measures 2.0 College and Career Readiness evaluation, 91 (33%) self-reported feeling more prepared to make future decisions about careers than they did higher education. Of the survey respondents, 58% said they learned how to prepare for an interview, and 70% said they learned how to act professionally because of engagement in 4-H. Because of 4-H, 59% said they have a better idea of what they may do after high school.</p>	
20.	<p>Supporting Parenting Education Benefits Communities</p>	<p>Issue: Parenting education reduces tax dollar expenditures by creating stable families, reduces reliance on public assistance, and addresses risky youth behaviors such as substance abuse including opioid misuses and early sexual activity (Bukoski & Evans, 1998). The Partnership in Prevention Science Institute research demonstrated that for every dollar spent on the Strengthening Families Program for Parents and Youth ages 10 to 14 (SFP 10-14), \$9.60 comes back to the community as benefits in less jail time, less time off work, and less time in treatment. Parent involvement and academic support are</p>	<p>Human Potential and Youth Development</p>

		<p>important for youth to succeed in school. Additionally, better couple relationships lead to better parenting which in turn leads to better child outcomes.</p> <p>Response: 84 Human Sciences Extension and Outreach staff and community partners trained and delivered research- and evidence-based parenting education curricula across Iowa to parents and couples. The onset of the pandemic changed the delivery mode from face-to-face to a virtual environment. Curricula (with number times presented) included: SFP 10-14/Familias Fuertes (14); Small Talk, Raising School Ready Readers (2); Healthy Relationship and Marriage Education Training (2); ELEVATE (2); Science of Parenting (4); ACT Raising Safe Kids (2); Salir Adelante (3); Juntos Para Una Mejor Educación (Together for a Better Education) (4); Abriendo Caminos (3); parent cafes (3); and other parenting efforts (1). In total, these curricula were delivered 40 times and reached 378 parents.</p> <p>Results: 94% (n=6) of parents and couples completing an evaluation survey after participating in ELEVATE improved their relationship skills. 100% (n=14) of HRMET participants reported feeling confident or very confident that they are better equipped to help couples develop and maintain a healthy and committed relationship, support healthy living choices, manage differences and conflicts, and become better connected with their support systems. 95% (n=378) of parents completing an evaluation survey after participating in sequenced research –and/or evidence-based Extension and Outreach parenting education curricula improved their parenting skills (e.g., self-care, monitoring children/youth, developmentally appropriate expectations). Iowa parents who participated in Small Talk increased the language provided to their children by approximately 30% over comparison families who frequented the library but did not participate in Small Talk. Among the 71 youth who participated in Juntos Para Una Mejor Educación (Together for a Better Education) or Salir Adelante, 23 youth enrolled</p>	
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		<p>in 4-H for the first time, 32 youth and their parents visited one or more colleges, and 6 youth enrolled in college. Additionally, two parents of the youth completed a GED.</p>	
<p>21.</p>	<p>Increasing Childcare Providers' Use of Early Childhood Quality Health and Safety Practices</p>	<p>Issue: Iowa currently ranks as one of the leading states for the percentage of young children with employed parents. 75% of Iowa families with children under age 6 have all parents in the household working. Demand is high for quality early childhood programs. The average full-time annual income for a childcare worker is below \$23,000. Workforce turnover is reported at 65% annually and most childcare professionals have limited training in early childhood education. Research has shown the early years in a child's life represent a critically important window of opportunity to develop a child's full potential and shape key academic, social, and cognitive skills that determine a child's success in school and life.</p> <p>Response: Nine I-Learn Early Childhood Education (ECE) Online programs met the increasing need for accessible on-line education in the area of health and safety practices, serving childcare professional from all 99 counties. Early Childhood Environment Rating Scale (ERS) classes include instruction, self-assessment, and guidance in developing program quality plan with optional formal assessment. The New Staff Orientation (NSO) Online program provided 16 hours of instruction for childcare center staff and program directors. 44 Child Care Resource and Referral consultants participated in consultant credential and mentor credential program. 76 childcare provider early learning workshop were taught face-to-face in 18 Iowa counties.</p> <p>Results: A total of 24,260 childcare professionals reported individual and program improvements. 7,019 Essentials Child Care Preservice Online participants successfully demonstrated knowledge gains in health, safety, and child development. 369 teachers and 54 directors participated in the NSO program and completed portfolios with statistically significant ($p < .001$) gains in each of the 11 NSO outcomes. 518</p>	<p>Human Potential and Youth Development</p>

		<p>Environment Rating Scale participants completed self-assessments and initiated program improvement plans. A retrospective survey of Early Childhood Environment Rating Scale participants (n=497) indicated that 96% of participants could better identify strengths and limitations, prioritize changes, and had initiated a workable plan for program improvement. Environment Rating Scale assessments were conducted to document the quality of 137 childcare classrooms. A total of 14,461 individuals completed Universal Precautions for Child Care training with an 80% quiz pass rate. An additional 2,000 early childhood professionals participated in childcare community and online workshops. Of the surveyed participants (n=1,832), 93% reported or demonstrated improving learning environments or teaching practices.</p>	
<p>22.</p>	<p>Strengthening Financial Management Practices in Times of Financial Volatility</p>	<p>Issue: Financial insecurity has grown, and 23.4% of Iowa households experience income volatility, which is unreliable, inconsistent, and fluctuating income resulting from job loss, unreliable employment, and irregular work (Prosperity, 2021). Households face growing pressures to set realistic financial goals and manage resources carefully. They find it hard to plan and budget each month and to put aside savings. As a result of the pandemic, many households face significant financial uncertainties.</p> <p>Response: To help alleviate financial stress and increase financial security, Human Sciences Extension and Outreach’s research-based programs incorporate features that help Iowans improve financial knowledge, change financial behavior, and take action. In this program year, approximately 5,681 individuals (including 85 youth) attended targeted financial education programs. 12 HSEO staff delivered approximately 165 programs on basic financial on basic financial management practices, including planning, record-keeping, organization of financial and personal records, credit management, insurance, investing and retirement planning. Almost 21,000 individuals were reached indirectly with relevant, timely financial management information using alternative platforms (a blog, mass media and web-based publications. Nine HSEO staff delivered four train-the-trainer programs (Small Change; Your Money Your Goals;</p>	<p>Human Potential and Youth Development</p>

		<p>Cent\$ible, VITA) targeting professionals and volunteers to build their skills, knowledge, and confidence to financially empower their constituents.</p> <p>Results: Educators administered pre-post-and follow-up or retrospective pre-post program evaluations during the delivery of sequential financial education programs. Evaluation data demonstrated improved financial management practices. 85% of surveyed participants (385 of 454) reported at least one improved financial management practice. Participants in Making Ends Meet reported developing spending plans, tracking expenses, and identifying ways to reduce expenses. Adults approaching retirement who attended Retirement Planning programs reported setting an income target for retirement, calculating their retirement benefits, and identifying sources of retirement income.</p>	
<p>23.</p>	<p>Helping Clients Reach Financial Stability and Self-Sufficiency</p>	<p>Issue: Financial capability programs can increase helping professionals’ confidence to integrate financial empowerment into their outreach, improve ability to access hands-on tools and unbiased information, and increase ability to help others manage their financial goals and challenges (Compen et al, 2019). Programs can increase the knowledge and skills of educators, library staff, social service workers, and Volunteer Income Tax Assistant (VITA) volunteers. VITA volunteers help Iowans access the Earned Income Tax Credit (EITC), an effective policy for reducing poverty. An estimated 20% of Iowans who are eligible do not receive it (more typically in rural areas, self-employed, or with a disability) an average return in Iowa was \$2,300 in 2019 (IRS, 2020).</p> <p>Response: With 10 specialists, Human Sciences Extension and Outreach amplifies its educational efforts with train-the-trainer programs that provide training, materials, and resources for social service workers, educators, and volunteers to use with clients to help them take steps toward reaching financial stability and self-sufficiency. Your Money, Your Goals training provided a hands-on, interactive opportunity to understand the importance of</p>	<p>Human Potential and Youth Development</p>

		<p>financial empowerment. Five Small Change programs were offered to Iowa K-12 educators and focused on building personal financial management skills and connecting these professionals with vetted curricula, web-based resources, and model programs. VITA volunteers were supported in the successful completion of education and testing required by the Internal Revenue Service (IRS).</p> <p>Results: 22 faith-based and community-based agency personnel and volunteers completed the 6-hour Your Money, Your Goals workshop. 86% of participants (12 of 14) who completed a post-workshop survey reported knowing where to go for unbiased information or help in working with the people they serve, to help people manage their financial challenges, and provide the right financial content at the right time in the context of their work with clients on financial management issues. 143 teachers and school personnel participated in a month-long blended course involving a 2-hour workshop followed by four weeks of game-based online learning. 97% percent (91 of 94) who completed the post-survey reported being better prepared to identify and use trustworthy financial literacy resources in their work. 56 VITA volunteers successfully completed IRS certification exams and completed 1,243 tax returns which yielded \$1,031,472 of Earned Income Tax Credit (EITC) refunds. EITC refunds positively impact change in households and communities thus improving financial security.</p>	
<p>24.</p>	<p>Beef producers utilizing cover crops</p>	<p>Issue: Establishing cover crops following removal of grain crops is a proven tool to protect soil, reduce erosion, improve water quality, and enhance soil health. There is a synergy between grain production and cattle operations, which can be capitalized on when cattle producers incorporate cover crop grazing into their operations. This synergy also provides an opportunity for grain producers to diversify their farm operation with livestock.</p> <p>Response:</p>	<p>Natural Resources and Environmental Stewardship</p>

		<p>Since 2017, at various beef extension meetings, we have provided education on utilizing cover crops as forage for cattle. Topics at meetings have included integration of cover crops into row crop acres as a forage resource, using cover crops for soil conservation, species selection, seeding methods, and proper termination. Additional topics included forage quality, potential cattle health risks, fencing and water limitations, expected cattle performance, and extending grazing days. In 2020, evaluations were distributed to 263 livestock producers across the state who had attended a beef extension meeting discussing cover crops within the past 3 years. 69 participants completed an evaluation: response rate of 26%.</p> <p>Results: Following the three years of extension education on utilizing cover crops as a forage resource, 80% of producers responding to the survey reported adopting this practice and seeing benefits to soil conservation, grazing opportunities, and feed cost reductions. From implementing cover crops on their own farms, 58% noted that they experienced a decrease in soil erosion, 48% experienced improvements in soil health including water infiltration and nutrient retention, and 39% experienced winter feed cost savings. Additionally, individual respondents also noted boosts in yield of row crops following cover crops, a decreased cost of gain, fuel savings, and improved calf health from utilizing the cover crops as a calving area to keep calves out of mud in the spring. Survey respondents identified the following opportunities as potentials for further increasing the use of cover crops in their farming enterprise: ability to extend the grazing season, an additional feed resource, soil health and conservation benefits, and increased diversity on the farm.</p>	
<p>25.</p>	<p>Investigations into Aquatic Resources Biology, Ecology and Management</p>	<p>Issue: There remains a need to provide current data to construct conservation management plans based on inherent genetic diversity of rare and endangered species; how these same animals adapt to Iowa's changing landscape; and which aquatic species have the best potential to serve public need and desire for aquaculture products.</p>	<p>Natural Resources and Environmental Stewardship</p>

		<p>Response: During this project period we conducted basic research into how aquatic animals adapt to changes in their environment, used historical and field analysis of current nutrient inputs into aquatic systems in Iowa, and created new information about the use of aquaculture species for community fisheries.</p> <p>Results: Results garnered from this research will be used by public agencies to make the needed changes in their management of Iowa's landscape, whereby water quality is improved and aquatic organisms can enable native species to survive and prosper. Societal benefits include improved water quality for human and animal use, and sustained populations of aquatic animals in Iowa's highly modified landscape. Ultimately, improved environmental conditions and fisheries management will increase natural resource user satisfaction that often results in increased ecological and economic value of these resources.</p>	
<p>26.</p>	<p>Interaction of cropping systems with their environment in the central United States</p>	<p>Issue: One research focus this project period was the impact of adoption of biomass crops on loss of crop nutrients to regional water bodies. The perennial growth cycle of bioenergy crops alters the cycling of key nutrients within and through the exported flow of soil water, as compared to annual crops, such as corn and soybean. As climate variations continue to impose extremes in weather patterns, complications and challenges associated with managing large areas with perennial vs annual agroecosystems may have a significant impact on environmental water dynamics and water resources (VanLoocke et al., 2016).</p> <p>Response: Computer simulation work is now complete. We have successfully conducted simulations of land use change associated with varying aspects of the Renewable Fuel Standard at both the regional and water shed scale. We have also conducted a more precise profit-based water quality analysis for the Raccoon River Basin in Iowa. Results</p>	<p>Natural Resources and Environmental Stewardship</p>

		<p>indicate that, at the Mississippi River Basin scale, production of miscanthus on economically viable land would be unlikely to improve water quality to the extent targeted by the Environmental Protection Agency's Hypoxic Zone Task Force. This is because most of the land where miscanthus would be produced is outside of the areas that are currently losing the most nutrients to the Gulf of Mexico. We conducted an additional economically constrained model simulation that did not allow for corn stover to be used as a source of cellulosic biofuels. In this case there was more miscanthus on higher nitrate-leaching land and the water quality improvements were greater.</p> <p>Results: Such information is essential not only to determine the continued viability of Iowa's present agricultural system, but also to determine a range of future adaptive agricultural strategies including the potential or necessity for alternatives to the present maize-soybean dominance of Iowa agriculture.</p>	
<p>27.</p>	<p>Population ecology and conservation of vertebrate and invertebrate organisms</p>	<p>Issue: Studies of the ecology of many wildlife species, and how individual species interact with each other, are of interest to wildlife and conservation biologists. As human population growth continues, many native communities will become increasingly threatened and there will be an even greater need for managing rare and declining species.</p> <p>Response: We measured wildlife demographic responses and linked them to the distribution, abundance, and richness of wildlife populations. We also documented wetland impacts for birds (secretive marsh-birds and migratory shorebirds) that resulted in changes in how Iowa manages shallow lakes and flood control reservoirs for broader wildlife benefits. Lastly, we documented pesticide impacts on the nest survival of two songbirds that has important implications for understanding climate change impacts to birds. This new knowledge was shared with our partner organizations, which included The Nature Conservancy, U.S. Army Corps of Engineers, ISU Department of Aerospace</p>	<p>Natural Resources and Environmental Stewardship</p>

		<p>Engineering, Iowa Department of Natural Resources, North Carolina State University, Oregon Biodiversity Information Center, U.S. Bureau of Land Management, U.S. Environmental Protection Agency, U.S. Geological Survey, and the U.S. Fish and Wildlife Service.</p> <p>Results: The work completed under this project has increased our knowledge of the current status of wildlife populations, estimates of wildlife diversity and abundance, and how wildlife species and communities respond to management and conservation actions. Outcomes include current estimates of important vital rates (survival, nest survival, dispersal probability) for non-game and game species, new and refined methods to survey wildlife populations, increased understanding of habitat and other influences on vital rates, and new characterizations of wildlife-habitat relationships, linked to specific management recommendations, all with a particular emphasis on working (agricultural) landscapes in the Midwest. Our wildlife-habitat work will directly impact how local wildlife managers alter wildlife habitat (for many non-game and game species), increase public awareness of wildlife (establishing a local birding trail), and will allow us to predict species occurrence patterns to guide future conservation efforts.</p>	
<p>28.</p>	<p>Monarch Butterfly Conservation</p>	<p>Issue: Decline in the monarch butterfly over the past decade in North America has been precipitous and well documented. Many Iowa farmers recall past monarch aggregations as they migrate in the fall and regret the loss of this biological phenomena. Iowa is in the critical summer breeding zone of the monarch butterfly and therefore optimizing habitat for monarch butterfly life stages can have a significant impact on butterfly conservation.</p> <p>Response: Our studies evaluated the extent to which larvae move on and between ramets (a group of genetically identical plants) and the extent of intraspecific competition of larvae on the same milkweed stem. Intraspecific competition is when two or more individuals of</p>	<p>Natural Resources and Environmental Stewardship</p>

		<p>the same species simultaneously demand use of a limited resource. Results to date indicate that larvae leave their natal ramet during the fourth of five stages of growth, even though sufficient biomass remains on the plant. These results indicate isolated milkweed stems will likely not support development through pupation—the fifth stage. These and other findings were shared as a part of our activities with the NC1205 multi-state project, were published in the Journal of Insect Conservation, and were shared with stakeholders in a covid-19 environment through social media and on-line presentations at scientific meetings. Analyses of studies assessing intraspecific competition of monarch larvae are on-going. Monarch larvae engage in cannibalism during starvation and as the instar age span increased, cannibalism was more frequent. A second study determined how larval density and limited food availability played a role in larval cannibalism, which rarely happened under more favorable conditions. A third study established egg cannibalism among all instar stages. Additional analyses are also addressing results from experiments refining best practice for establishing common milkweed in brome. Preliminary results show that planting rhizomes is most successful; results to date also suggest that milkweed only patches in a bromedominated landscape can connect other patches and larger restorations.</p> <p>Results: Research this period advanced techniques to monitor and assess milkweed density in roadsides and evaluate causes of adult mortality during the fall migration. Published studies improved understanding of larval monarch growth and development in habitat patches with different milkweed densities and documented a potential method to evaluate continental dispersion of adult monarchs based on mitochondrial genome-wide variation. These findings were shared with stakeholders in a covid-19 environment with social media and on-line presentations at scientific meetings. This work aids in the development of monarch conservation practices and will inform the future USFWS Endangered Species Act listing decision and associated conservation practices being developed by USDA and stakeholders in agricultural communities.</p>	
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<p>29.</p>	<p>Development in Automation and Sensors for Sustainability of Specialty Crops</p>	<p>Issue: A rapidly increasing world population and changing climate means plant scientists will need to be able to efficiently develop crop varieties to feed the world. Although the technology for sequencing the genomes of plants has advanced, the technology for characterizing the physical traits of plants has remained relatively static. This gap in technology has become known as the “Phenotyping Bottleneck.” To close this gap, researchers are working to develop robotic systems that can efficiently recognize various physical traits of plants.</p> <p>Response: A navigation controller for the field-based plant phenotyping platform - PhenoBot 3.0 was developed. Both under- and above-canopy vision-based row detection algorithms and navigation control algorithms were developed and field tested during summer of 2020. Machine learning algorithms for stalk (StalkNet) and leaf angle (AngleNet) detection for maize and sorghum plants were developed; and in conjunction with our customized PhenoStereo 3D sensor, highly accurate stalk size and leaf angle measurements were obtained. Results were shared during activities with the W3009 multistate project and through technical papers, including journal publications and conference presentations, primarily at the Phenome 2020 conference in February, Tucson, AZ and the annual international meeting of American Society for Agricultural and Biological Engineers in July (virtual). Presentations were also given to farmers and domestic and international visitors.</p> <p>Results: The success of PhenoBot 3.0 development will provide an automated solution for field-based phenotyping of row crops, particularly those tall-growing crops like maize and sorghum which are substantially more difficult to phenotype under field conditions. PhenoBot 3.0 will greatly facilitate phenomics research in understanding the interactions between genomics and environments.</p>	<p>Transformative Technology</p>
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