2017 Michigan State University Combined Research and Extension Annual Report of Accomplishments and Results

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I. Report Overview

1. Executive Summary

Michigan State University (MSU) AgBioResearch (ABR) scientists and MSU Extension (MSUE) specialists provide science-based knowledge to improve food and quality of life, as well as to generate economic viability and enhance sustainability. They are also committed to finding solutions to meet growing food demands with fewer resources.

The need for targeted research and outreach in the areas of agriculture and natural resources is immense. With emerging threats such as antibiotic resistance, bovine leukemia, spotted wing drosophila and other invasive pests, agriculture producers face a plethora of on-farm issues, many of which have human health implications. At a time when the growing world population is projected to exceed 9 billion by 2050, our global food supply needs to double to meet demands within that same timespan.

ABR conducts leading-edge research that combines scientific expertise with an understanding of real-world problems in the key areas of food, health of humans, animals and plants, and the environment. The research strives to find viable, workable solutions in many diverse areas from entomology and packaging to microbiology and nutrition. The multidisciplinary projects are led by more than 330 scientists from the following MSU colleges:

- Agriculture and Natural Resources
- Natural Science
- Veterinary Medicine
- Engineering
- Social Sciences
- Arts and Letters
- Communication Arts and Sciences

An integral part of the pioneer land-grant university, ABR maintains a balance between basic and applied research and relies heavily on constituent and stakeholder input from the agricultural and natural resources industries to identify priorities. An emphasis is placed on integrated and multidisciplinary endeavors with programs continually evaluated for relevance and progress to meet the changing needs of both the agriculture and natural resources industries. The accomplishments and discoveries outlined in this report are reflective of some of the reasons why ABR (founded as the Michigan Agricultural Experiment Station) continues as one of the most successful entities of its kind 125-plus years after its formation.

A vital component of the land grant mission, Michigan State University Extension (MSUE) disseminates the research knowledge to people to improve lives through an educational process that applies knowledge to critical issues, needs and opportunities. One of the hallmarks of MSUE is its willingness and ability to adapt programming to meet the needs of Michigan residents, communities and businesses.

The food and agriculture industry in Michigan is estimated to contribute more than $100 billion to the state's economy (direct, indirect and induced) and accounts for more than an estimated 923,000 jobs. Food and agriculture represent about 22 percent of the workforce in Michigan. With more than 300 commodities, 55,000 farms and 10 million acres of farmland, Michigan also has one of the most diverse agricultural industries in the nation. The state ranks second in the U.S. in terms of its crop diversity from fruit, vegetables and soybeans to ornamental trees, livestock and fish.

Michigan farmers, ABR scientists and MSUE educators continue to be asked to accomplish more with less. Conversely, challenges with pests, plant diseases, processing logistics, shifting climates and the need for consumer education have become increasingly complex and more demanding. Leveraged and external funding is more important and more competitive to secure than ever before. ABR scientists and MSUE educators continue to demonstrate flexibility, innovation and a perseverance that equips them to respond to these challenges.

The federal government's **$18 million** investment from the National Institute of Food and Agriculture capacity funds and associated dollars to Michigan State University (MSU) AgBioResearch and MSU Extension generated nearly **$1.1 billion** for Michigan residents in FY 2017-2018, according to an analysis by Steven Miller, Center for Economic Analysis, MSU Department of Agricultural, Food and Resource Economics.
It also revealed that for every $1 the federal government invested in MSU AgBioResearch and MSU Extension, the organizations:

- **LEVERAGED $10.82** of state funds, external contracts, grants and other revenues that serve Michigan residents.
- **RETURNED $21** of community benefits through education programs and research.
- **58:1 BENEFIT/COST RATIO** when state funds, community benefits and economic stimulus are combined, the estimated benefits to Michigan residents and the nation exceed the initial federal investment.

Reach and engagement, included:

- More than 149,000 adults and 212,000 youth participated in MSU Extension programming in the most recent year.
- Last year, nearly 1.9 million newsletters covering90 topic areas were distributed to more than 53,000 email addresses.
- More than 5.3 million people viewed more than9.8 million pages on the MSU Extension website. Of those, more than 1 million were Michigan residents.
- More than 330 AgBioResearch scientists from seven different colleges conducting leading-edge research.

The success and accomplishments of ABR and MSUE are fueled by close partnerships with each other, as well as linkages to state agencies, commodity groups and other stakeholders, and outstanding legislative support. This collaboration is crucial as researchers and outreach specialists continue to tackle and address issues that rarely respect geographical borders such as food safety, invasive species and plant and animal diseases.
https://www.canr.msu.edu/research/2017-accomplishments

Some key project areas, include:
MSU Product Center - Fueling the Economy
Creation of new businesses, especially in the food/agriculture sector, has become important to the economic development of Michigan. Communities and businesses can benefit from the expertise and resources of higher education in developing and expanding services and product s. Understanding the value of food and agriculture to Michigan's economy is key.

MSU Extension and AgBioResearch partnered with the university and others in creating the MSU Product Center Food -Ag-Bio that fosters entrepreneurial development in the food, agriculture and bioeconomy. The MSU Product Center provides coordinated, university-wide assistance to help Michigan entrepreneurs develop and commercialize high-value, consumer-responsive products and businesses in the agriculture, food, natural resources and bioeconomy sectors.

MSU Extension staff members provided the following Product Center services during the 2017 calendar year:

- One-on-one client counseling sessions: 4,164 sessions
- Assistance with business concept development: 476 clients
- Venture start-ups (based on a commencement and continuation of planning for a new business or an expansion for an existing business): 282 clients
- Specialized services (including product testing, market analysis, and feasibility studies): 389 clients

Evaluation Results of Services

- Venture launches (commencement of economic activity for new or existing businesses through new sales, investment, or employment) : 91 ventures
- Increased annual sales (cumulative first-year sales only): $13.9 million
- Value of increased investment: $52.4 million
- Jobs created: 461
- Jobs retained: 486

Impacts from this work ranged from jobs for individuals to new business, services and products for Michigan residents.

Protecting Michigan's Fruit from Invasive Spotted Wing Drosophila

Michigan ranks first and fourth, respectively, in tart and sweet cherry production and third in blueberry production in the U.S. Both industries have a zero-tolerance policy for larvae in fruit. Detections of the invasive pest, spotted wing drosophila (SWD), result in rejection of fruit and economic losses for farmers.

Lab research indicates SWD can turn over a generation in as little as five days, allowing them to spread rapidly, having great potential to devastate Michigan's blueberry and cherry industries. SWD has been the primary pest in Michigan blueberries since 2011 and losses are rapidly growing in cherries, causing cherry growers to double pest management costs.

Research efforts at Michigan State University focus on finding the most effective management solutions for SWD. Controlling SWD requires significant changes in growers' traditional pest management practices, including when and how often to spray insecticides. MSU Extension offers workshops and educational meetings to assist growers with pest management decisions and reduce risks associated with SWD. Growers who attended the meetings indicated:

- 82% improved their SWD management knowledge.
- 92% of those growers indicated they used what they learned at our meetings and workshop to manage the SWD and other pests.
- 100% indicated SWD as their farm's major source of economic losses.
- 69% of growers participating in MSU Extension training reported no crop losses from SWD.

IPM training of growers is making the difference. Growers with access to MSUE IPM training are

successfully reducing crop losses due to insect pest problems such as SWD. That is critical to maintain Michigan's small fruit competitive. Also, for the sustainability of small farms and preservation of income and employment, especially for underserved, minority and new and beginning farmers. This is critical at the time when some growers that in 2016 & 2017 suffered extensive losses due to SWD are abandoning the industry.

Dining with Diabetes
Chronic diseases are among the most prevalent, costly and preventable of all health issues. Access to high-quality, affordable prevention measures is essential to saving lives, reducing disability and lowering costs of everyone's medical care. Michigan State University (MSU) Extension is positioned to provide education related to the prevention and management of leading chronic diseases of the state's citizens. Michigan ranks 15th nationally for diabetes prevalence and fifth nationally for obesity. More than nine percent of Michigan adults have been diagnosed with diabetes. Health care costs are 2.3 times higher for a person with diabetes as opposed to a person without diabetes. Moreover, 82 percent of older adults have at least one chronic condition, which puts a financial burden on the health care system.

Dining with Diabetes is a five-session course designed for people at risk of diabetes or who have diabetes as well as their family members. Through Dining with Diabetes, participants learn to prepare healthy meals using less fat and to make meals using less sodium and sugar without reducing flavor and enjoyment. They also learn the causes of diabetes, tools for managing diabetes, and the importance of diet and exercise in managing diabetes. The program offers opportunities to sample a variety of healthy foods and take home recipes to further encourage behavior change. During 2012, there were 11 Dining with Diabetes series held statewide reaching 80 people.

Reducing the prevalence and improving the management of diabetes is a public health concern for all Michigan citizens to reduce health care costs. Participants of MSU Extension PATH programs report significantly improved symptom management including decreased worry, decreased fearfulness about future health problems and fewer frustrations about health problems. At the end of the series, PATH participants show decreased symptoms of fatigue, decreased shortness of breath and decreased self-reported pain. Other program benefits show increased physical activity and improved communication with physicians including preparing a list of questions to ask during a health care visit. Participants report higher self-efficacy after attending the program and show improved self-rated health scores.

Evaluation results found:

- 76% fit exercise into their daily routine
- 56% exercise continuously for at least 30 minutes at least three times a week
- 63% participate in physical activity such as walking on a daily basis
- 81% cook more at home
- 94% eat smaller proportions
- 77% are using recipes provided by the program

Participants of Dining with Diabetes programs showed improved attitudes about healthy eating including understanding the role of glucose, fiber, carbohydrates and fats in their bodies. As a result of the Dining with Diabetes classes, participants report improved control in menu selections such as considering servings sizes, using food labels and limiting the amount of carbohydrates consumed.

Supporting MSU Extension disease prevention and management education programs helps participants increase their ability to lead a healthy lifestyle and that greatly reduces a person's risk for developing chronic disease or improves disease management. The cost of treating diabetes is expected to triple in Michigan over the next 25 years. It is estimated that the state can save $545 million spent across all chronic diseases by investing $10 in preventive care per person, per year (Dall et al. The Economic Burden of Diabetes. Health Affairs 29(2): 1-7, 2010).

MSU opens new center for urban food systems in Detroit
A Detroit neighborhood will host Michigan State University's first urban food research center, developing solutions to economic and nutritional challenges unique in urban environments.
The MSU Detroit Partnership forFood, Learning and Innovation willbreak ground in 2018 at the site of the former Houghton Elementary School in the Riverdale neighborhood near Brightmoor. Urban-focused research areas envisioned for the center include soil sampling and pollution cleanup, pest and crop disease management, forestry, innovative growing systems and community food systems development. The center continues MSU's 100-year tradition of working with Detroit partners to offer free or low-cost programs that meet community needs. MSU is working closely with neighborhood residents to determine programming focus areas.

Managing, preventing the spread of bovine leukemia virus
MSU experts estimate that more than 40 percent of U.S. dairy cows are affected with bovine leukemia virus (BLV) -- a retrovirus that causes infection in dairy and beef cattle leading to a higher likelihood of other disease development -- compared to 10 percent in the 1970s.
Researchers and MSU Extension educators have conducted studieson how to best manage BLV-infected animals and discourage further transmission. In Michigan alone, economic losses from BLV total roughly $14 million per year.

- MSU senior Extension educator Phil Durst examined the prevalence of BLV in 38 dairy herds around Michiganin order to bolster awareness of the disease and options for mitigating its effects.
- MSU researchers Paul Coussens and Paul Bartlett have sought to uncover how BLV negatively affects dairy cattle immune system function.

MSU Institute of Agricultural Technology expands partnerships, programs
The MSU Institute of Agricultural Technology (IAT) experienced an11 percent increase in its student population last year and now involves 11 community colleges throughout the state.
The two-year certificate program helps students develop their understanding of agriculture, the environment and applied technologies through intensive, practical education and skill enhancement to ensure that they are prepared to enter challenging and rewarding careers in agriculture.

- The food and agriculture industry contributes over $101 billion and 923,000 jobs to the state's economy each year.
- Approximately 47 percent of the agriculture jobs in Michigan relate to food processing.
- The Michigan Workforce Development Agency made a $43 million investment to upgrade the MSU Food Processing Education Laboratory into a state-of- the-art facility to train students.

Supporting pollination in agriculture
The U.S. Department of Agriculture (USDA) estimates that one-third of agriculture in the United States, valued at approximately $40 billion per year, depends on pollination by bees, butterflies and other insects. Some crops, including apples, cherries and blueberries, are approximately90 percent dependent on pollination by bees.
New challenges such as habitat loss and fragmentation, pesticide use and disease pressure have caused declines in both managed and natural pollinator populations nationwide.

- MSU entomologist Rufus Isaacs ledthe Integrated Crop Pollination (ICP) Project, a nationwide, multi-institutional research project to investigate the performance, economics and farmer perceptions of various pollination strategies across a range of fruit and vegetable crops.
- ICP conducted a wide-ranging outreach e ort, holding talks with growers and producing informational

resources, including regional fact sheets, guides and videos at icpbees.org.

• To maximize pollinator activity, ICP researchers recommend establishing wildflower plantings near agricultural fields to provide pollinators with habitat and additional sources of sustenance. Reducing mowing and tilling around the borders of fields also protects underground bee nests and allows native flowering plants to develop.

Key areas of interest for AgBioResearch in 2017:

The stories below are parts of stories featured in our 2017 Annual Report. Full stories are linked in the title of each article.

Preserving hardwood diversity through new management

http://www.canr.msu.edu/news/preserving-hardwood-diversity-through-new-management

In the early days of Michigan statehood, it was a common belief that a squirrel could easily cross the entire state without ever setting foot on the ground because of the plentiful forests. Though much of that landscape has since changed, forests remain tremendously important to Michigan's economy and culture. With the state boasting approximately 20 million acres of woodland, Michigan's forest products industry includes more than 800 logging and trucking companies, and over 1,000 manufacturers that depend on Michigan lumber, according to the Michigan Department of Natural Resources (MDNR). The density and diversity of those forests are dwindling, however, and a Michigan State University (MSU) AgBioResearch team is working to remedy that.

For the past half-century, the majority of Michigan's northern hardwood forests were managed using a method called single tree selection silviculture. In this practice, emulating the dynamics of old-growth forests, loggers enter a stand of woodland every 10 to 20 years, cutting down single trees and leaving small gaps in which the ecosystem would naturally replenish itself. This should have led to diverse ages among the trees, but forest managers returning to stands over decades discovered that they remained fairly even aged. Instead of rejuvenating the stands, they were effectively thinning them out, threatening the long-term sustainability and diversity of the forests.

Species diversity protects the forest ecosystem from threats such as pathogens and insect predation because what targets one species has less impact on others. A healthy, resilient forest, therefore, features a wide assortment of trees, from the commercially and ecologically significant sugar maple to yellow birch, red maple and others. Single tree selection combined with high deer population, has been found to have a homogenizing effect, limiting the species that are able to regenerate. Worse still, those species that do regenerate tend to be less preferable economically and environmentally, such as American beech and ironwood.

Taken together, these issues represent a threat to one of Michigan's most important natural resources. That's why the MDNR approached MSU AgBioResearch forest ecologist Michael Walters for help. Walters has dedicated his academic career to developing better, more sustainable ways of managing forests.

Understanding, preventing transport of plant pathogens in water

http://www.canr.msu.edu/news/understanding-preventing-transport-of-plant-pathogens-in-water

A soil physicist at Michigan State University (MSU), Wei Zhang, is drawn to some of the most challenging problems facing modern-day agriculture. He heads the Soil and Water Research Lab at MSU, a group of scientists tasked with identifying ways to utilize soil and water resources more efficiently.

How do we grow a greater quantity of healthy food for a rising world population? How can we address antibiotic resistance? How can we act as better stewards of the environment and reduce contamination? Zhang and his team aspire to answer these questions and to tap into the vast plant science expertise at MSU outside of his lab.

In March 2012 -- just a couple of months after Zhang started at MSU -- he attended a presentation given by Mary Hausbeck, a renowned plant pathologist and University Distinguished Professor in the MSU Department of Plant, Soil and Microbial Sciences. She has served the Michigan vegetable and greenhouse ornamental industries for nearly three decades, tending to crop disease issues as a

researcher and MSU Extension specialist.
Hausbeck spoke to her colleagues about Phytophthora and Pythium, water molds that wreak havoc on a wide range of crops. Spores from these molds -- called zoospores -- can travel through water and infect neighboring plants, a chain reaction that can quickly devastate a grower's operation.
Zhang primarily deals with the transport of contaminants within soil and water, so he believed this presented a collaboration opportunity to delve into plant diseases.

Estimating effects of genes: One size may not fit all
http://www.canr.msu.edu/news/estimating-effects-of-genes-one-size-may-not-fit-all
For decades, animal breeders have benefited from databases of livestock performance information on economically important traits such as milk yield or reproductive performance, along with pedigree, to accurately predict genetic merit of animals. Genotype information using single nucleotide polymorphism (SNP) markers available within the past decade, particularly in dairy cattle, has further increased their accuracy and the ability to select younger animals for breeding stock, thereby doubling genetic gain in milk yields per year.
One of the surveyors of heredity is Rob Tempelman, professor of quantitative genetics and animal breeding in the Michigan State University (MSU) Department of Animal Science and recipient of the 2017 Jay L. Lush Award in Animal Breeding from the American Dairy Science Association.
Tempelman describes his work as an attempt to enhance research reproducibility while recognizing that genetic effects and their as-sociations with economically important traits can vary widely across different environments.

Lupus: Preventing onset from an environmental trigger
http://www.canr.msu.edu/news/lupus-preventing-onset-from-an-environmental-trigger
According to the National Institutes of Health, more than 23 million Americans have an autoimmune disorder, a condition in which the body's immune system attacks healthy cells by mistake. Dozens of diseases fall under the autoimmune category -- lupus, rheumatoid arthritis, Type 1 diabetes and multiple sclerosis are some of the most common -- and none have cures.
Symptom relief and management are currently the primary strategies for medical professionals, but the healthcare community is working hard to determine the underlying causes.
Michigan State University (MSU) researcher James Pestka, the Robert and Carol Deibel Family Endowed Professor in the Department of Food Science and Human Nutrition, is collaborating with other MSU scientists to uncover the secrets of autoimmunity.
Focusing on lupus, Pestka and his colleagues used funding from the National Institute for Environmental Sciences and the Lupus Foundation of America to conduct studies that showed how consuming the omega-3 fatty acid DHA can prevent the activation and progression of the disease when the cause is exposure to a toxic environmental substance.
DHA is inherent in many popularly consumed fish species and is also present in fish oil supplements taken daily by millions of people around the world.
Lupus, like other autoimmune disorders, is believed to be the result of a multitude of influences, including genetics and the environment. The illness is more common in those who have worked in industries such as construction and mining, where workers may come in to contact with certain substances.

Developing new cropping systems to help Michigan vegetables survive extreme weather
http://www.canr.msu.edu/news/developing-new-cropping-systems-to-help-michigan-vegetables-survive-extreme-weather
Michigan vegetable producers are facing an increased incidence of extreme weather events -- such as drought, heat and heavy rainfall -- that place extreme stress on crops. New cropping systems are needed to help reduce the risks associated with these events.
Daniel Brainard, associate professor in the Michigan State University (MSU) Department of Horticulture, is undertaking a range of research projects to build resiliency in vegetable crops. He is looking at reducing tillage and maintaining crop residues on the soil surface, two principles basic to conservation agriculture.

His current projects include several long-term trials exploring the best way to implement strip tillage systems to build soil health, increase moisture retention and protect tender crops, and develop new irrigation systems to reduce heat and drought stress for historically nonirrigated Michigan vegetables.
Strip tillage involves tilling fields in straight lines separated by a strip of untilled soil where a cover crop may be planted. For some crops, such as carrots, the cover crop strip can protect the cash crop when plants are small and vulnerable. When the cover crop dies and is left on the soil surface, it acts as mulch and helps to preserve soil moisture and prevent erosion.
With support from other MSU specialists and MSU Extension educators, Brainard's long-term strip tillage trials have shown beneficial increases in soil organic matter and improvements in soil moisture under drought conditions, along with reduced labor and fuel costs for tillage.

Flint water crisis: Hearing the community's concerns
http://www.canr.msu.edu/news/flint-water-crisis-hearing-the-community-s-concerns
In large-scale crises, scores of well-intended individuals and organizations often flock to disaster areas to lend a hand to those in need. These groups often come equipped with ready-made short-term solutions to what are typically broad, systemic problems.
But gaining understanding of the problem from those experi-encing it is vital to improving the situation. In the rush to find answers and "help" amidst great uncertainty, the voices of those affected can be lost in the chaos.
Michigan State University (MSU) researchers found this to be the case during the Flint water crisis. To provide immediate as-sistance, thousands descended upon the city with bottled water and other supplies. At a deeper level, however, the situation from the perspectives of Flint residents was not fully under-stood. Primarily through the MSU Office of Outreach and Engage-ment, the university has longstanding relationships throughout Flint with organizations such as the Community Foundation of Greater Flint (CFGF).
Artina Sadler, the food system navigator and program manager with the CFGF, had taken part in participatory modeling work at MSU through events such as the Innovations in Collaborative Modeling Conference. Participatory modeling is a computation-al approach that brings together various perspectives on major health and environmental issues to solve complex problems.
After learning more about participatory modeling, Sadler and the CFGF invited an MSU team to work in the city. MSU would bring the modeling expertise, and the CFGF would organize four work-shops in distinct areas of Flint and one citywide meeting for a project dubbed Voices of Flint.
During the spring and summer of 2016, Flint residents were invited to attend various sessions to speak about their experiences. More than 60 participated, filled out surveys and collaboratively represented the complex dynamics of the issues, primarily identifying the causes, consequences and potential solutions to the crisis.
"It was extremely important that we frame this work as an exercise in lis-tening," said Steven Gray, an assistant professor in the MSU Department of Community Sustainability. "We came into an emotionally charged situation, and we needed to respect that. The people of Flint were, and still are, dealing with traumatic circumstances."
Key areas of interest for Extension in 2017:
Evaluation results from 2006 and 2016 Issue Identification process that involved over 10,000 Michigan residents found current and past customers of Extension rated satisfaction high (86% in 2006 and 90% in 2016). Regression analyses found community priorities related to satisfaction, especially community development, agriculture, food safety and supply, and youth development (see https://www.canr.msu.edu/od/planning_evaluation_and_reporting/needsassessmentresults2.pdf?language_id=1)
MSU Extension has four Institutes with work teams that build plans (see https://reporting.anr.msu.edu/miprs2018/stateplan.pdf) for team members to link to as well as identify local initiatives. In 2017, MSUE served 148,048 adults and 219,468 youth and utilized over 17,000 volunteers.
Agriculture and Agribusiness Institute educated 42,534 adults
- 2,907 adults educated in Animal

- 9,219 adults educated in Consumer Horticulture
- 6,312 adults educated in Field Crops
- 3,396 adults educated in Fruit
- 2,010 adults educated in Ornamental Horticulture
- 3,43 adults educated in Vegetable
- 12,246 adults educated in Public Event, Breakfast on the Farm, Ag Literacy, Consumer Ed, etc.

Children and Youth Institute educated 219,468 (unduplicated) youth and 9,773 adults with 12,835 adult volunteers

- 88, 406 youth trained in Animals
- 80,965 youth trained in Food and Nutrition
- 66,910 youth trained in Environmental Education/Earth Sciences
- 40,161 youth trained in Leadership and Personal Development
- 32,628 youth trained in Communication and Expressive Arts
- 24,555 youth trained in Ag in the Classroom
- 22,808 youth trained in Plant Science
- 15,594 youth trained in Community Service and Civic Engagement
- 3,708 adults trained in Child and Family Development
- 3,096 adults trained in Capacity Building
- 1,479 adults trained in Leadership and Civic Engagement
- 893 adults trained in Career Education and Workforce Preparation
- 597 adults trained in Science

Greening Michigan Institute educated 30,610 adults

- 10,940 adults trained in Community Foods Systems
- 4,337 adults trained in Natural Resources Stewardship
- 5,363 adults trained in Government and Public Policy
- 1,049 adults trained in Entrepreneurship
- 5,422 adults educated in Michigan Sea Grant
- 3,163 adults educated in Finance/Homeownership
- 336 adults trained in Tourism

Health and Nutrition Institute educated 65,131 adults

- 2,314 adults trained in Disease Prevention and Management
- 9,222 adults trained in Food Safety
- 48,096 adults trained in Nutrition and Physical Activity
- 4,865 adults trained in Social and Emotional Well-Being
- 634 adults trained in Extension Health Research

Diversity, Equity, and Inclusion Efforts and Collaborations

• Hiring and onboarding of Quentin Tyler as Associate Dean and Director for Diversity, Equity and Inclusion. Dr. Tyler brings DEI scholarship and experience that is focused on our Agriculture and Natural Resources disciplines, as well as nationwide professional relationships to help the College coordinate both our diversity recruitment, and the retention of outstanding faculty, staff and students.

• Diversity, Equity, and Inclusion trainings for College leadership, including a full day retreat, to apply Diversity, Equity, and Inclusion concepts to existing structures and processes in the College of Agriculture and Natural Resources.

• Seated and convened permanent standing College Advisory Committee on Diversity, Equity and Inclusion to examine workplace policies and create

• Faculty and academic specialist were invited to apply for microgrants that had a specific focus on promoting diversity, equity and inclusion. The activities may include; visits to strengthen ties with Tribal colleges, Hispanic Serving and Minority Serving Institutions in an effort to facilitate research and/or enhance the recruitment and retention of underrepresented students, faculty and staff at CANR, participation in workshops that lead to the development of effective teaching strategies for the educational

advancement of students from groups underrepresented in higher education, participation in faculty workshops to promote equity and inclusion in the classroom, participation in scholarship of teaching and learning activities including workshops, research projects, conferences at the intersection of curriculum development and diversity, participation in university pipeline and/or outreach activities, participation in conferences, national organizations that have an emphasis on diversity, equity, and inclusion.

• Each New Faculty member is required to provide an inclusion statement as part of that application process. The inclusion statement focuses on how the candidate can contribute to as a scholar to a diverse, equitable, and inclusive environment at CANR.

• Each Faculty Search Committee is provided an Affirmative Action Charge by the Associate Dean and Director for Diversity, Equity, and Inclusion. The search committees are also charged with selecting an affirmative action advocate and keeping diversity, equity, and inclusion in mind when reaching out to potential applicants.

Future Events in Diversity, Equity and Inclusion

• Associate Dean and Director for Diversity Equity and Inclusion has begun "Time to Talk" series. 1). Scheduled meetings with the leadership of each department/unit in the College of Agriculture and Natural Resources to discuss challenges and opportunities in Diversity Equity and Inclusion. 2). An online survey will follow for each faculty, staff, and student to assess the climate of the department/unit and college. 3). Faculty, staff, and student town hall meetings will follow in each of the departments. 4). Concluding, each department will be providing recommendations on building a diverse and inclusive department. Content of the recommendations will include specific trainings, programs, speakers, recruitment, onboarding, and retention strategies for each meeting.

• Spring of 2019, Co- Host with Iowa State University a Convening of Professionals that work in Diversity, Equity, and Inclusion Training for Colleges of Agriculture, and Natural Resources scheduled for April 3, 2019 in Overland Park, Kansas.

• Spring of 2019, College of Agriculture and Natural Resources first Intercultural Awareness Day event that focuses on the learning and development of faculty and staff in the area of religion. Selecting one faculty and staff per department to participate in a community tour and panel of various religions and presentations. As a result, each faculty and staff will be responsible for providing feedback of their respective experience to their department at a subsequent department meeting.

• Multicultural Summer Cooperative Extension Summer Intern Program is being formed with an intentional focus on diversifying MSUE.

Total Actual Amount of professional FTEs/SYs for this State

Year: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	195.0	0.0	65.0	0.0
Actual	221.6	0.0	87.0	0.0

II. Merit Review Process

1. The Merit Review Process that was Employed for this year

- Internal University Panel
- External University Panel

- External Non-University Panel
- Expert Peer Review

2. Brief Explanation

ABR and MSUE goals must remain fluid and flexible to meet the constant changes in the agriculture and natural resource industries. Research goals are continually evaluated for relevance and impact at local, state and regional levels. Strategic priorities address the research needs of the Michigan agriculture and natural resources industries, but are also linked to national and global goals and initiatives.

Through strategic planning with ABR-affiliated colleges, MSUE staff and key stakeholder groups, priority areas are reviewed annually. This process involves industry experts, university faculty, MSUE and ABR advisory council members and research center advisory committee members, as well as scientific review by peers (local, national and international). MSUE uses several continuous processes that assist in setting priorities and evaluating program goals and plans. At the local level, the interested public, government officials, advisory group members and industry experts are involved in broader stakeholder processes, as well as the review of individual educator plans. These goals and plans are also reviewed by state leaders and industry experts for quality and relevance and by the ABR and MSUE directors, who not only evaluate them, but use them in regional and statewide presentations to explain future plans.

Jointly, ABR and MSUE address issues of concern in communities with research and teaching by using a network of citizen advisory groups at the local and state levels. Fourteen district MSUE councils identify and prioritize issues, seek collaborations and resources and communicate to others the importance of MSUE educational programming. Citizen Advisory Councils help establish research priorities at the 13 outlying ABR centers and 18 on-campus facilities. The MSUE-ABR Council serves as liaison among district councils, research center advisory groups and state agencies and organizations.

III. Stakeholder Input

1. Actions taken to seek stakeholder input that encouraged their participation

- Use of media to announce public meetings and listening sessions
- Targeted invitation to traditional stakeholder groups
- Targeted invitation to non-traditional stakeholder groups
- Targeted invitation to traditional stakeholder individuals
- Targeted invitation to non-traditional stakeholder individuals
- Targeted invitation to selected individuals from general public
- Survey of traditional stakeholder groups
- Survey of traditional stakeholder individuals
- Survey of the general public
- Survey of selected individuals from the general public
- Other (Conferences and meetings, social media)

Brief explanation.

A variety of strategies and approaches were used in the past year to encourage stakeholder participation for numerous key activities and undertakings. ABR and MSUE continue to develop the framework for new, industry-supported partnerships:

• The Michigan Alliance for Animal Agriculture (M-AAA) is in its fourth year as a partnership among the MSU College of Agriculture and Natural Resources, ABR, MSUE and Michigan animal agriculture commodity organizations. The partnership has evolved from roughly $600,000 in grant funding from Michigan State University (MSU) in the first two years to a combination of funding from MSU, commodity organizations and the state of Michigan, totaling more than $1.5 million last year. In 2018, that commitment will grow even more, as the state has budgeted $2.5 million to M-AAA. With the MSU and commodity organization funding included, $3.1 million is available to enhance research and outreach efforts, which speaks to the value our partners have seen in our work thus far. The increased funding is helping researchers confront some of animal agriculture's most pressing issues, such as protecting the environment, combating antibiotic resistance, managing infectious diseases and improving animal welfare.

• Project GREEEN (Generating Research and Extension to meet Economic and Environmental Needs) commits to funding outreach and research programs that align with the plant-based agricultural priorities of growers and entrepreneurs throughout the state. This cooperative effort between ABR, MSUE, the Michigan Department of Agriculture and Rural Development and grower-led commodity organizations supports Michigan's growing plant-agriculture industry by providing targeted research and Extension programming in the face of evolving challenges.

ABR and MSUE participated in several trade shows to engage with growers and producers and help business owners learn profitable and efficient business and production practices by planning programs that benefit agriculture and agribusiness. The Great Lakes Fruit, Vegetable and Farm Market Expo is an excellent example:

• MSUE and ABR educators serve as leaders of the programming committee that creates up to 70 educational sessions over a three-day period.
• The event attracts more than 4,000 growers and agriculture professionals annually from 42 states and eight Canadian provinces.

The MSU Product Center is a great example of investment in people. Fundamental to the missions of ABR and MSUE is working with entrepreneurs to grow businesses, create jobs and strengthen the economic vitality of individuals and communities. Food and agriculture are a driving force in Michigan's economy, with an MSU Product Center Food-Ag-Bio report showing that the agriculture system generates more than $100 billion of economic activity every year.

The MSU Product Center strengthens this important sector of the economy by connecting food entrepreneurs with innovation counselors who offer the latest research and best practices, identify markets, innovate new products and help guide the process from concept to launch. The center's statewide network of counselors helps both new and established businesses deliver high-value products to consumers in Michigan and throughout the United States.

In 2016-17, MSU Product Center professionals conducted 4,164 counseling sessions with 689 clients, resulting in:

• Nearly $53.4 million in total capital formation, including more than $4.6 million of owner capital investment in Michigan businesses.
• 91 new ventures launched.
• 947 jobs created or retained.

MSUE encourages growth in a sustainable and prosperous Michigan food and agriculture system by

training industry and agency professionals to keep their skillsets current with proven science.

• Thanks to a grant from DuPont Pioneer, staff worked with their counterparts from the University of Wisconsin to train Pioneer agronomists to determine best practices to improve soil health, such as planting cover crops and reducing tillage and compaction.
• To date, more than 80 agronomists in Michigan, Ohio, Indiana and Iowa have been trained. The feedback tells us agronomists value this model because it allows them to work with growers on improving soil health and better advise them on practice changes that will increase soil health.
• Using that same model, we also trained 90 people with the U.S. Department of Agriculture Natural Resource Conservation Service and Michigan Conservation District.
• Our educators created an on-line training program for Pioneer Seed that staff members can use when they consult with growers.

ABR and MSUE partner with state agencies and growers to battle invasive pests. For several years, we have led the charge to fight spotted wing drosophila and brown marmorated stink bug, two insects that threaten Michigan fruit production. Through these partnerships, we have been able to monitor these pests, in hopes of controlling and eliminating these invasive species.

Fourteen district advisory groups help in collecting local stakeholder input and assist in the development of priorities. Further, numerous individual meetings were held with staff, stakeholder advisory groups and the ABR-MSUE State Council related to the development of MSUE institute areas and what they should be. Meetings were also held with the Michigan Association of Counties, the Michigan Townships Association and state legislators.

In addition, MSUE and ABR continue to strengthen its collaboration with the North Central Region to identify common issues among stakeholder input, pool resources and improve multi-state efforts. Finally, MSUE utilized information from the 2016 issue identification process. Institute Work Teams have taken this feedback and data to change their plans that have included things like more research and education on GMO's, pollinators, career exploration, water sheds, financial literacy, reaching new and underserved audiences, and more.

2(A). A brief statement of the process that was used by the recipient institution to identify individuals and groups stakeholders and to collect input from them

1. Method to identify individuals and groups

- Use Advisory Committees
- Use Internal Focus Groups
- Use External Focus Groups
- Open Listening Sessions
- Needs Assessments
- Use Surveys

Brief explanation.

To conduct leading-edge research that results in practical solutions, ABR and MSUE rely on input from an extremely broad and long list of stakeholders and partners. Such feedback is generated by representatives in the following industries:

- Agricultural
- Food and food processing
- Natural resources

- Bioeconomy industries
- State residents
- Non-profit organizations
- Businesses
- Governmental organizations
- Universities

An emphasis is placed on keeping key internal and external stakeholders (e.g., agricultural producers, commodity groups, food processors and the tourism, fisheries and forestry industries), legislative contacts and the interested public abreast of issues, and using a blend of traditional and online platforms to reach individuals and groups and collect input from them. The Advance Michigan statewide online issues identification process that was completed in the fall 2011, the previous Strengthening Michigan's Economy comprehensive survey before it, and other ongoing outreach efforts offer multiple ways for people in various roles and locations to help identify the issues and opportunities for ABR priorities and MSUE educational programming in the years ahead.

Community-based discussions in all Michigan counties, involving local advisory committees, the MSUE-ABR councils and others are held to discern what issues and opportunities stakeholders believe should be addressed related to research and programming. Citizen focus groups are also used to identify issues and opportunities in Michigan and assign a priority ranking to each. Community groups, commodity and producer groups and other state and local partners are periodically asked what issues and opportunities should be explored and addressed.

Faculty member focus groups, with representatives from Michigan colleges and units, are held as needed to glean perceptions on emerging Michigan issues and opportunities and to identify ways that MSU science projects and/or initiatives might address them. MSU faculty members and ABR/MSUE staff surveys are used as needed to develop a better understanding of the university's ability to respond to issues identified in faculty focus groups. County teams, including ABR center managers, synthesize and prioritize content specific program and research needs identified by the various councils and advisory committees. Working groups within each institute synthesize and prioritize content-specific program and research needs generated from the input of their advisory bodies and develop programs to meet these needs, as well as methods for evaluating their impacts. Needs are fine-tuned as additional input is received.

2(B). A brief statement of the process that was used by the recipient institution to identify individuals and groups who are stakeholders and to collect input from them

1. Methods for collecting Stakeholder Input

- Meeting with traditional Stakeholder groups
- Survey of traditional Stakeholder groups
- Meeting with traditional Stakeholder individuals
- Survey of traditional Stakeholder individuals
- Meeting with the general public (open meeting advertised to all)
- Survey of the general public
- Meeting with invited selected individuals from the general public
- Survey of selected individuals from the general public

Brief explanation.

Stakeholder input provides the foundation for the research and educational programs developed by ABR and MSUE. Stakeholders help decide the future direction for ABR through programs such as

Project GREEEN, the Michigan Alliance for Animal Agriculture (M-AAA) and commodity advisory teams. There are extensive conversations and visits that also take place throughout the year with local, state and federal officials and commodity group and industry representatives from the agricultural, natural resources and renewable energy industries.

For MSUE, town hall meetings, individual meetings, feedback via email, blogs and surveys and new formed District Advisory groups are all being used to inform the newly restructured MSU Extension, including the priorities that should be set under each of the four new institutes. More specifically, the past two years was spent collecting input from county commissioners. A series of meetings was held with commissioners across the state. A task force was then set up to help determine how the partnership could work. The task force met and then sent a mailing (that also included a url to a website with additional information) to all county commissioners, inviting them to participate in several webinars to discuss the Memorandum of Agreement that was being put together to formalize the partnership. A survey was also sent out to all commissioners, laying out three scenarios on how to approach the partnership. Survey participants were asked which of the options they preferred and how they thought it could be implemented to ensure that the right costs are allocated to the counties and to MSU Extension. Based on this feedback, changes were made. The MOU (Memorandum of Understanding) was executed in FY 2012 in 80 counties.

For ABR, multiple meetings were held with commodity groups, legislators and key stakeholders representing the key agricultural sectors as work continued with the consolidation of management and operations for various research centers and units. In addition to these traditional, long-standing venues, an ad hoc committee comprised of faculty members and commodity group stakeholders was established to conduct a comprehensive review of ABR centers and to provide recommendations on how to best move forward in implementing needed changes.

3. A statement of how the input will be considered

- In the Budget Process
- To Identify Emerging Issues
- Redirect Extension Programs
- Redirect Research Programs
- In the Staff Hiring Process
- In the Action Plans
- To Set Priorities

Brief explanation.

From an operational perspective, ABR has used stakeholder input to guide its decision-making process around the consolidation and restructuring of its 13 ABR centers and 18 on-campus centers. MSUE utilized the stakeholder input in forming the four institutes and the 16 work groups that guide them. The input has been useful in setting priorities and focusing on more with fewer resources.

Brief Explanation of what you learned from your Stakeholders

The following are a few of the takeaways ABR and MSUE has learned from its stakeholders:

• Food safety and security and a safe and secure water supply are critical priority areas for research activities.
• Newer technology is necessary to continue to build and maintain strong partnerships both internally and externally.

• Research and information dissemination efforts are critical to the success of the $100 billion food and agriculture industry in Michigan.
• Solutions and innovations will be even more critical in the future for residents in Michigan, the nation and the world.
• Genetic research needs to be a critical area of focus.

IV. Expenditure Summary

1. Total Actual Formula dollars Allocated (prepopulated from C-REEMS)			
Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
{No Data Entered}	{No Data Entered}	{No Data Entered}	{No Data Entered}

2. Totaled Actual dollars from Planned Programs Inputs				
	Extension		Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	9459345	0	6244548	0
Actual Matching	9459345	0	6524213	0
Actual All Other	0	0	40237824	0
Total Actual Expended	18918690	0	53006585	0

3. Amount of Above Actual Formula Dollars Expended which comes from Carryover funds from previous				
Carryover	2301060	0	0	0

V. Planned Program Table of Content

V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

Human Health, Environment, Family, Youth, Society and Community

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
608	Community Resource Planning and Development	5%		7%	
702	Requirements and Function of Nutrients and Other Food Components	0%		7%	
703	Nutrition Education and Behavior	20%		0%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources	0%		10%	
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins	0%		12%	
721	Insects and Other Pests Affecting Humans	0%		8%	
723	Hazards to Human Health and Safety	0%		9%	
724	Healthy Lifestyle	25%		12%	
801	Individual and Family Resource Management	10%		0%	
802	Human Development and Family Well-Being	10%		8%	
803	Sociological and Technological Change Affecting Individuals, Families, and Communities	0%		7%	
805	Community Institutions, Health, and Social Services	0%		12%	
806	Youth Development	30%		8%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	103.4	0.0	11.5	0.0

Actual Paid	127.0	0.0	11.0	0.0
Actual Volunteer	58.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
5097834	0	810696	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
5097834	0	847003	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	5223858	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Research programs to:

• Develop a better understanding of public benefits for policy development in recreation and tourism resource management.
• Increase understanding about how environmental pollutants, especially ozone and endocrine disruptors affect human health.
• Establish new programs and policies to help young people move successfully from foster care to independent living after they are too old for foster care.
• Analyze the relationships among social support, public policy and family characteristics and how they affect the function and well-being of rural low-income families.
• Increase understanding and develop more effective environmental management systems.
• Develop better models for the human health and human services sectors.
• Identify the nutritional determinants of allergic immune disorders.
• Develop an understanding of how n-3 polyunsaturated fatty acids affect human health and disease, especially cardiovascular disease and inflammation. ....

Educational programs to:

• Teach how to choose healthful food, physically active lifestyles and behaviors consistent with dietary guidelines.
• Teach consumers to keep their food safe by offering programs on food safety, home food preservation and healthy, hygienic food-handling practices.
• Teach people living with chronic medical conditions to manage their condition effectively.
• Teach financial literacy and prepare individuals to manage their finances in anticipation of retirement.
• Teach caregivers and parents how to prepare children for school.
• Increase access to affordable, high-quality childcare.
• Prepare communities for the health care, housing and transportation needs of seniors.
• Educate citizens and public officials about funding methods, service provision and intergovernmental cooperation.
• Provide counties and municipalities with technical assistance related to intergovernmental contracting,

consolidating services and financial and strategic planning.
- Assist government officials in leadership, conflict management, communication and engaging the public in policy development.
- Prepare youth with knowledge and skills needed for life and employment.
- Enhance the physical, social, emotional and cognitive health and well-being of youth.

2. Brief description of the target audience

Michigan private citizens, state agencies, farmers, food processors, commodity groups and agricultural industry representatives are targets of research programs. Individuals of all ages and life stages are targeted for healthy lifestyle and food-safety education programs. Human development and family well-being programs target parents and caregivers of preschool children, people living with chronic medical conditions and senior citizens. Community institutions, health and social services programs target citizens and public/government officials. Youth age 9 to 18 are targets of youth development programs.

3. How was eXtension used?

MSU Extension continues to utilize eXtension as one of the primary multi-state activities that involve contributing to Communities of Practice, responding to Ask an Expert questions, and contributing to innovation projects. One example in this area was conducting a webinar help military families learn about personal finances (see https://militaryfamilies.extension.org/personal-finance/).

V(E). Planned Program (Outputs)

1. Standard output measures

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	68211	204633	51076	51076

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2017
Actual:	1

Patents listed

MICL02257, Hierarchical Genetic and Environmental Regulation of M. tuberculosis Complex Persistence. SN 62/404,492

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	0	37	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research programs on human health, environment, family, youth, society and community.

Year	Actual
2017	38

Output #2

Output Measure

- Number of adult participants trained in healthy lifestyles.

Year	Actual
2017	50410

Output #3

Output Measure

- Number of youth participants trained in healthy lifestyles.

Year	Actual
2017	36321

Output #4

Output Measure

- Number of youth participants trained in life skills.

Year	Actual
2017	12796

Output #5

Output Measure

- Number of adult participants trained in family resource management.

Year	Actual
2017	2070

Output #6

Output Measure

- Number of youth that gain knowledge in how to respond to one's own social-emotional needs and the social-emotional needs of others

Year	Actual
2017	552

Output #7

Output Measure

- Number of adult participants trained in youth development.

Year	Actual
2017	9773

Output #8

Output Measure

- Number of adult participants trained in home ownership education and foreclosure counseling.

Year	Actual
2017	1093

Output #9

Output Measure

- Number of youth participants trained in financial literacy and money management.

Year	Actual
2017	2074

Output #10

Output Measure

- Number of adults trained in human development and family well-being.

Year	Actual
2017	4865

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of research programs to determine the relationship between family meals/lifestyle factors, education/food choices, general health and environmental influences, physical activity and general health.
2	Number of research programs to understand how environmental pollutants, especially ozone and endocrine disruptors, affect human health.
3	Number of research programs to develop better models for the human health and human services sector.
4	Number of adult participants with increased knowledge about healthy lifestyles.
5	Number of youth participants with increased knowledge about healthy lifestyles.
6	Number of adult participants with increased knowledge of human development and family well-being.
7	Number of youth participants with increased knowledge of life skills.
8	Number of adult participants with increased knowledge of youth development.
9	Number of research programs to develop more effective environmental/natural resources management systems.
10	Number of adult participants with increased knowledge of family resource management.
11	Number of research programs that study the function of nutrients and other components related to human health.
12	Number of youth that change in their ability to respond to one's own social-emotional needs and the social-emotional needs of others
13	Number of youth participants that increase knowledge in financial literacy and money management.
14	Number of adult participants with increased knowledge in home ownership education and foreclosure counseling.

Outcome #1

1. Outcome Measures

Number of research programs to determine the relationship between family meals/lifestyle factors, education/food choices, general health and environmental influences, physical activity and general health.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	9

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Diabetic retinopathy is a major complication of diabetes severely affecting vision. To date the disease is neither curable nor are there sufficient treatment options available that can reliably control disease progression and symptoms. Given the increasing number of diabetic patients, there is a pressing need to develop more efficient therapeutic strategies.

What has been done
Research to: improve human, animal and plant health; understand the relationship between cancer and diet; assess allergenic potential of food; understand inflammation and the development of diabetic retinopathy; explain how diet, obesity and inflammation impact colon cancer risks; understand how diet and environment impact liver disease and heart health; understand how incentives work to impact social norms and behavior.

Results
Studies to identify receptor levels of membrane bound and soluble forms of receptors involved in IL-6 signaling on human retinal Müller and endothelial cells; Evaluation of STEC genotypic and phenotypic variation in cattle and humans and knowledge of additional factors important for bovine colonization and human disease will facilitate development of effective prevention and intervention methods useful for the agricultural, food, and health care industries.

4. Associated Knowledge Areas

KA Code	Knowledge Area
703	Nutrition Education and Behavior

724	Healthy Lifestyle
802	Human Development and Family Well-Being
806	Youth Development

Outcome #2

1. Outcome Measures

Number of research programs to understand how environmental pollutants, especially ozone and endocrine disruptors, affect human health.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One of the great challenges of the 21st century is to improve human well-being while reducing stress on the environment. In order to meet this challenge, we must have a better understanding of what factors influence well-being and what factors drive human stress placed on the environment, and in particular how the two are related to one another. This project seeks to advance our knowledge of what matters in shaping well-being and what drives stress placed on the environment at levels ranging from the individual and the household to the state, region and nation. It places particular emphasis on understanding the influences that can be shaped via effective policy so that research results can inform public and private sector decision making.

What has been done
Research to: understand inhalation toxicology of air pollution in rural communities, understand the roll of environmental stress and human well-being ; and understand lymphoid cells in air pollutant induces asthma and rhinitis.

Results
We have one paper using US state level data examining the effects of inequality on sustainability that is being revised in response to a revise and resubmit and anticipate two more papers using this approach over the next two months. In another study, we demonstrated that 2-hour exposure to coarse PM in a rural setting promotes an acute elevation in BP, most likely due to increased sympathetic nervous system activity as supported by changes in heart rate variability (HRV).

4. Associated Knowledge Areas

KA Code	Knowledge Area
723	Hazards to Human Health and Safety
805	Community Institutions, Health, and Social Services

Outcome #3

1. Outcome Measures

Number of research programs to develop better models for the human health and human services sector.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	9

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The National Guard (NG) forces are an integral component of the United States (US) military, representing up to 40% of troops deployed to recent conflicts. NG service members and their families have unique circumstances distinguishing them from their active duty counterparts. The largest stressors for these citizen soldiers entail transitions into and out of active duty status including changes in health benefits and long-term job security as they return to the civilian work force post-deployment. Unlike their active-duty counterparts - surrounded as they are by large military communities, a chain of command, family support groups, dedicated military hospitals, military chaplaincy, employment stability, child care, and the shared experiences of their neighbors - NG families often face life after deployment largely alone in communities who know little about their struggles. Thus, family often takes on singularly massive importance for service members and the family members awaiting their return. The geographical dispersion of NG families throughout rural and urban communities can lead to isolation from formal and informal military supports. Family stress is often unavoidable due to disruptive changes in family structure resulting from shifting roles and relationships that occur throughout the NG life cycle. The pile-up of stressors, inexperience with military culture, and isolation, all leave NG families at greater risk for poor adjustment. Additional family strains can be exacerbated by mental health symptoms and related family difficulties, which are present in 40% of NG service members and 36% of spouses post deployment. Although there is a growing body of research related to our understanding of family wellbeing through the deployment cycle, there are still significant gaps in our knowledge, particularly when it comes to NG families. 3-6 The current program of research brings together an

interdisciplinary research team to explore factors within and outside of families that contribute to resiliency in the lives of NG service members and their spouses and children.

What has been done
Research to: transition young people who age out of foster care; develop healthcare packaging that is easier to access, particularly for aging consumers and people with disabilities; develop models for preventive and early intervention strategies for children living with a family member with a serious illness;examine the relationship between the number of foster home placements for youth and the number of community connections as emancipated adults;examine the relationships between emotion-related socialization behaviors and infants', toddlers' and preschoolers self-regulation and social-emotional competencies; and to develop models and family-based interventions that advance the well-being of National Guard soldiers and their families post-deployment to a combat zone; work to make breast cancer risk reduction messages more accessible to diverse groups.

Results
In one project, the proposed studies will contribute to our understanding of models of risk and resiliency for populations such as the military--families that are under significant life stress. In another, randomized controlled trial to determine whether community gardening increases fruit and vegetable consumption, physical activity, social support, and reduces age-associated weight gain and sedentary time among a multi-ethnic population of adults began in Denver, Colorado in January 2017.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development
802	Human Development and Family Well-Being
803	Sociological and Technological Change Affecting Individuals, Families, and Communities
805	Community Institutions, Health, and Social Services
806	Youth Development

Outcome #4

1. Outcome Measures

Number of adult participants with increased knowledge about healthy lifestyles.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	44361

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example is Responding to Stress in Farm Communities. The National Institute for Occupational Safety and Health recently examined 130
occupations and found laborers and farm owners had the highest rate of death due to stress-related conditions like heart and artery disease,
hypertension, ulcers and nervous disorders. In 2016, the CDC reports that out of every 100,000 farmer 90 commit suicide that is six times higher than the National rate of suicide with non-farmers. Michigan has seen an increase in suicides and suicide attempts over the last year since the commodity prices have fell drastically.

What has been done
MSU Extension has developed a workshop specifically designed for people who work with agricultural producers and farm families who want to know more about managing farm-related stress and learn ways to approach and communicate with those in need. Educators will be discussing the present agricultural market situation with an overview of how this has affected a farm?s financial situation and cash flow, communication techniques, highlighting impact of stress on our body and state of mind, providing information on how to recognize some warning signs of depression, self harm and mental illness.

Results
Since October 2016, communicating with Farmers under stress workshops have been offered throughout the state of Michigan and Indiana which included 501 participants.

As a result of the program, 76% of participants increased their understanding of the current agriculture financial situation; 88% increased their understanding of the impact that stress has on their
own bodies; 92% were able to recognize warning signs of depression, suicide, and mental illness; 96% learned where to send people for help in the community, and of those, over 60% said their awareness of community resources greatly increased. An example of one of the comments, "I grew up in a farming community and on a 5th generation farm. I have seen how stress influences farm life. This class helped to expand my knowledge/experience on this topic." Another example is "I am going to try and focus on the underlying messages farmers are giving me when they are upset and when I am on the farm working with them on things they are unhappy about."

4. Associated Knowledge Areas

KA Code	Knowledge Area
724	Healthy Lifestyle

Outcome #5

1. Outcome Measures

Number of youth participants with increased knowledge about healthy lifestyles.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	29057

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example, is youth need more information and hands-on opportunities to learn proper food preservation techniques. Often times youth are handling food for others as well as themselves that can lead to health issues.

What has been done
MSU Extension adopted the youth food preservation curriculum "Put It Up," developed by the National Center for Home Food Preservation at the University of Georgia. Put It Up is a series composed of six different food preservation methods: boiling water canning, making jam, pickling, freezing, drying, and pressure canning. Each method is divided into a beginner-level hands-on activity and an advanced hands-on activity. Lessons can be taught as a complete series or as stand-alone lessons.

Results
In 2017. 487 youth were trained in food safety. Evaluation results found:
-95% of participants, upon completion, understood that food preserved via canning, pickling, or freezing remained safe to eat for longer than food left at room temperature.
-76% of youth gained knowledge about food spoilage organisms, and that their growth is slowed/prevented by low (freezing) and high (canning) temperatures.
-97% of youth participants reported that they would use science-based recipes when preserving food in the future.

4. Associated Knowledge Areas

KA Code	Knowledge Area
724	Healthy Lifestyle

806 Youth Development

Outcome #6

1. Outcome Measures

Number of adult participants with increased knowledge of human development and family well-being.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	4281

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example in this area is in the area of promoting health and wellbeing includes understanding important connections between physical, mental, social and emotional health. Emerging research and recommendations confirm ancient wisdom and science in showing that the false distinctions made between people's emotions, mental and physical health are both artificial and harmful. Wellness describes the entirety of one?s physical, emotional, and social health; this includes all aspects of functioning in the world (physiological, intellectual, social, and spiritual), as well as subjective feelings of well-being. (Robert Woods Johnson Foundation, 2014). How individuals handle their anger and stress affects a radius of people around them.

What has been done
MSUE developed the program called RELAX: Alternatives to Anger to help young people, parents and caregivers foster healthy relationships so they can live, learn and grow in a safe, affirming and fair environment free from violence, abuse, bullying and harassment. Youth, parents and caregivers learn to better manage their anger and stress at home and in the workplace. Through presentations, group discussion and skill-building activities, participants will learn what anger is, what triggers anger, calming down and de-stressing methods, the principles of problem solving, effective communication skills and forgiving and letting go of the past. This multi-session program can be provided in a variety of community educational settings.

Results
During 2017, evaluations were returned at the end of RELAX series Results found more than half of program participants leave with improved
knowledge or new skills designed to promote social and emotional well-being with others in their lives and immediate social environments. Highlights from the program evaluation of 231 participants were:

-64% reduced their frequency in yelling and screaming
-64% now work hard to be calm and talk things through
-63% talk things through until they reach a solution
-58% now know what triggers their anger at others

4. Associated Knowledge Areas

KA Code	Knowledge Area
802	Human Development and Family Well-Being

Outcome #7

1. Outcome Measures

Number of youth participants with increased knowledge of life skills.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	11260

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example in this area is skills for exploring careers and the process of obtaining employment. On a needs assessment survey of over 10,000 Michigan residents (customers and non-customers) found in both 2006 and 2016 found of 36 community priorities, the top priority was preparing today's youth for tomorrow's job.

What has been done
One program example of career exploration is the Michigan 4-H State Awards Program. The purpose of The 4-H State Awards Program is to recognize 4-H youth for engaging in rich learning experiences that result in outstanding knowledge and life-skill development. Goals of the 4-H State Awards Program youth were:
-Learn to better communicate and represent their accomplishments on professional applications such as scholarships, college-entrance applications, résumés and cover letters for employment.
-Have more experience and be better able to communicate during job interviews
-Build long-lasting friendships and establish connections with industry and academic leaders
-Be encouraged to set new goals, continue building skills and assets, and broaden interests

Results
Evaluation data was collected following the 2017 4-H State Awards Program. Evaluations were sent via email to 88 delegates; 31 responses were returned. Highlights of evaluation data:
-65% of participants indicated the program helped them prepare for an interview; 26% indicated they learned some about preparing for an interview
-100% of participants indicated they learned something about how to act professionally; 80% responding yes, 20% responded sort of
-58% of participants indicated they learned how to network with peers and professionals through the experience; and additional 32% worked on their networking skills
-87% of participants indicated the program had some or alot of influence on their decisions about college

Participant feedback regarding the impact of the program:
-The leadership program was valuable because now I know what the interview process is going to be like.
-It was good to have experience going through the application and interview process because now I feel miore prepared in my job and college search.
-I really liked how the judges gave feedback. By using their feedback I know what I need to improve on.
-I've never done a professional interview like that, so it was a great experience.
-Networking is so valuable, an you can do it anywhere always.

4. Associated Knowledge Areas

KA Code	Knowledge Area
806	Youth Development

Outcome #8

1. Outcome Measures

Number of adult participants with increased knowledge of youth development.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	7329

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example in this area is helping adults educate youth on science concepts and careers. There is a need to provide science literacy training for adults so they have the skills/knowledge to share this information at their local level.

What has been done
MSUE 4-H conducted a workshop in the Upper Peninsula to help build skills in educating youth about natural resources and their environment.

Results
The evaluation results showed that:
-53% of participants said they were quite a bit/A lot more knowledgeable about natural resources and the environment as compared to 38% before the workshop.
-64% of participants responded they are more knowledgeable about science as compared to 46% prior to the workshop
-80% of participants said they planned to use the new knowledge about natural resources and the environment.

4. Associated Knowledge Areas

KA Code	Knowledge Area
802	Human Development and Family Well-Being
806	Youth Development

Outcome #9

1. Outcome Measures

Number of research programs to develop more effective environmental/natural resources management systems.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
As the federal government, states, and urban municipalities recede from delivery of services, rural communities and neighborhoods within cities are increasingly responsible for ensuring the

maintenance and improvement of quality of life. The ability to do this is often tied to decisions about management of natural resources -- whether in the form of urban greening, food production, and food distribution, local energy conservation and development, or management of local water and saninfrastructure.

What has been done
Research to: better understand public benefits for policy development in recreation and tourism resource management; and to better understand the current spread, historical distribution and future disease risk of Lyme disease to inform effective citizen-focused information campaigns; identify sustainable ways to enhance human well-being while reducing stresses on the environment; understand large scale biodiversity in human dominated landscapes.

Results
Better understanding of the role of structural inequality in driving community level access to water and sanitation; Better understanding of the interconnection better technical, ecological, and social mechanisms that influence access.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development
723	Hazards to Human Health and Safety
803	Sociological and Technological Change Affecting Individuals, Families, and Communities

Outcome #10

1. Outcome Measures

Number of adult participants with increased knowledge of family resource management.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	1759

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One issue in this area is that Michigan families continue to struggle with income and debt issues. Unemployment numbers are lower than they have been since before the Great Recession of

2008. However, wages continue to slag and people still struggle to save money. Medical insurance premiums have continued to increase while energy costs have continued to stay low. Families need skills and information to manage their family finances and resources.

What has been done
MSUE developed a money management course with the overarching goal to help Michigan consumers become aware of their personal financial profile, to adopt sound financial and housing practices ? including managing spending and savings plan and utilizing financial products and services in a beneficial manner.

Results
During 2017, MSU Extension reached 665 adults with educational programs on managing personal and household finances. Program delivery ranged from 60 minutes to 180 minutes per session, with the average session lasting 120 minutes. Number of sessions ranged 1 to 5. Average age of participants was 37 years and 62% were women. Annual income was less than $18,000 for 62% of the participants. Participants employment status was 31% unemployed and 43% employed part- or full-time. Most (45%) rented, 14% lived with family, and 22% were homeless. Ten percent had experienced home foreclosure in the past few years. 42% expect to purchase a home in the next 3 years. Participants self-reported their race/ethnicity and the program reached 76% white, 16% black, 2% Hispanic, and 4% Native American. Three percent were Veterans. Pre- and post- program evaluations revealed participants improved and maintained knowledge on ten learning objectives and behavioral indicators of program outcomes.

As a result of the program (n=430):
-66% write SMART financial goals
-81% keep track of spending and income
-76% review all credit card bills and financial statements
-66% write out a spending plan
-76% save money regularly
-58% obtain and review credit report annually
-81% pay bills on time
-69% pay down debt or pay off new credit card charges each month
-63% obtain a housing payment that fits within a budget
-70% make choices today that will make retirement a reality

4. Associated Knowledge Areas

KA Code	Knowledge Area
801	Individual and Family Resource Management

Outcome #11

1. Outcome Measures

Number of research programs that study the function of nutrients and other components related to human health.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Obesity has risen at an epidemic rate in the United States and is recognized to increase colon cancer risk. Colon cancer is the second leading cause of cancer in the US. It is anticipated that with increased obesity colon cancer cases will increase; therefore, our research regarding how obesity increases the risk of colon cancer is extremely timely, important and will affect upcoming generations. Adipose tissue secretes hormones in the body that are important modulators of obesity and subsequent cancer risk. Reducing the production of these inflammatory mediators associated with obesity is a viable target for prevention of colon cancer associated with obesity. Dietary reduction of inflammation is a promising approach to cancer prevention. However, the hypothesis that diet changes will reduce inflammation associated with obesity has not been investigated.

What has been done
Research to: improve pregnancy outcomes related to food and environment; understand the role of lipid signs; improve meat quality, safety and nutritional values; to determine the effect of selected nutrients and food components on the development of allergic airway diseases; and understand genetic and environmental components of M. tuberculosis persistence.

Results
Adipose tissue secretes hormones in the body that are important modulators of obesity and subsequent cancer risk. Reducing the production of these hormones associated with obesity is a viable target for prevention of colon cancer associated with obesity. The
resulting research was published in 3 publications in 2016-2017. In another study, Previously, we estimated a LOAEL of 750 mg/kg of B.W. and a NOAEL of 500 mg/kg of B.W. based on laboratory rodents on
non-cancer effects. During this reporting period, we determined a NOAEL of 500 mg/kg B.W. for reproductive effects in rats or
mice. A LOAEL of 1000 mg/kg-day is determined for reproductive toxicity, based on in utero deaths and gross anomalies in F1
in rats.

4. Associated Knowledge Areas

KA Code	Knowledge Area
702	Requirements and Function of Nutrients and Other Food Components

723 Hazards to Human Health and Safety

Outcome #12

1. Outcome Measures

Number of youth that change in their ability to respond to one's own social-emotional needs and the social-emotional needs of others

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	498

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example is research has shown that practicing mindfulness is effective in reducing stress related symptoms such as worry, depression, and physical tension, and may be helpful in managing chronic conditions such as cardiac disease and diabetes. Mindfulness means paying attention in a particular way: on purpose, in the present moment, and non-judgmentally.Mindfulness introduces participants to the experience and practice of mindfulness to reduce stress.

What has been done
The MSU Extension program delivered a five-part series on mindfulness. During 2017, the educational series was taught by fourteen educators and instructors to 518 adults and 108 youth residing in 20 counties.

Results
A total of 272 program evaluation surveys were returned at the end of Stress Less with Mindfulness series with participants providing pre- and post- rankings of knowledge and self-reported behavior changes. As a result of the training, participants showed improvement on these nine program outcomes.

-98% can identify three mindfulness tools to help them manage stress.
-96% can identify their personal stress barometers.
-96% now use mindful breathing to calm themselves in the face of stress
-91% practice mindful movement as a way of calming the mind and body.
-91% use mindful awareness when eating
-96% describe how a mindfulness perspective can change reactions to daily stressors.
-95% are more positive about dealing with stress in their life by using mindfulness tools.

-94% plan to do something differently based on the information learned in the series.
-97% would recommend this educational series to someone else

4. Associated Knowledge Areas

KA Code	Knowledge Area
724	Healthy Lifestyle
802	Human Development and Family Well-Being
806	Youth Development

Outcome #13

1. Outcome Measures

Number of youth participants that increase knowledge in financial literacy and money management.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	1825

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Youth need skills in finances and money management to help them grow and develop into productive citizens.

What has been done
MSUE partnered with Chemical Bank and Michigan 4-H Foundation to provide training to both youth and adults and youth on financial literacy and money management.

Results
In 2017, MSUE educated 2,074 youth and 620 adults in financial education activities. Evaluation results found:

-99% understand that they are responsible for their financial future
-96% are confident about making future money decisions 93% have the skills to successfully manage their money
-89% practice self-control when making purchases

Many youth plan to practice good financial management practices after participating in this program, including:
-91% plan to ?pay themselves first? by saving a portion of the money they earn
-88% plan to buy their ?needs? first and limit buying their ?wants?
-82% plan to track the money they earn and the money they spend
-85% plan to look for the best deal when buying things
-56% plan to write down their savings goals for things they want to buy.

Youth comments were "In the next 6 months, I will be close to turning 16, so a new car will be needed soon! By taking this class, it has helped me learn how much more money and thought there is in buying a car." and "In the next 6 months when I am looking at colleges, I will consider how much I will have to pay back.".

4. Associated Knowledge Areas

KA Code	Knowledge Area
801	Individual and Family Resource Management
806	Youth Development

Outcome #14

1. Outcome Measures

Number of adult participants with increased knowledge in home ownership education and foreclosure counseling.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	962

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Home ownership can be difficult in maintaining during times of economic stress that Michigan has seen for over ten years. Intervention and counseling have been shown to help to alter the course of foreclosure and, in some cases, homelessness.

What has been done
Michigan State University Extension's Financial and Homeownership Education team developed

a foreclosure prevention and intervention education and counseling in collaboration with MSHDA and Department of Housing and Urban Development (HUD) that was implemented by certified housing counselors. These counselors work directly with Michigan residents, providing one-on-one information and options in addition to foreclosure. All counseling notes and outcomes were reported into Home Counselor Online (HCO), an online database created by Fannie Mae and used by foreclosure counselors.

Results

During 2017, seven FHE counselors assisted clients in 17 Michigan counties to resolve mortgage and tax delinquency issues. From that total, 298 participants from 242 total households were assisted with mortgage and property tax delinquency and default counseling by FHE?s certified counseling staff. Of the 208 total households who received foreclosure counseling services in 2017 and have reported counseling statuses and outcomes, 23 percent (n=48 out of 208) are still actively working with Michigan State University Extension counselors. Of that total, eight percent (n=5) are still receiving counseling services over half (n=27) are waiting to hear back from their service provider. Ninety-eight percent of the households achieving housing outcomes (n=136) were able to keep their current home. Of that total, seventeen percent (n=23) were able to bring their mortgage current, three households (n=3) entered forbearance agreements with their mortgage company, almost seven percent (n=9) modified or refinanced their mortgage into an affordable payment, thirty-five percent (n=48) received Step Forward Michigan funds to bring their mortgage or property taxes current, and almost twenty-nine percent of the households (n=39) initiated a repayment plan to begin to pay back their mortgage and/or owed property tax.

4. Associated Knowledge Areas

KA Code	Knowledge Area
801	Individual and Family Resource Management

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

During the 2016-17 fiscal year, ABR and MSUE support many areas such as our Enviro-weather stations. To assist Michigan producers with pest, plant production and natural resource management decisions, Enviro-weather provides weather data from a network of stations located throughout the state. Enviro-weather data are shared with other weather groups across the region and are also used in college and university classrooms to teach students about topics such as weather, agriculture and pest management. Since the creation of the Enviro-weather program, data requests have grown from 96 on average per day to more than 450 in 2015.

Project GREEEN funds supported:

- Two tower stations added to the Enviro-weather network to provide real-time, cross-sectional temperature and wind information to fruit growers for monitoring low-level inversions and making decisions related to wind machine-based frost protection.
- Along with the two tower sites, three additional standard stations were added within the past year: Benona/Shelby, Michigan; Kewaunee, Wisconsin; and Grant, Michigan.
- Operational upgrades including strategic network and system modernization, as well as routine weather network maintenance.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

As Hatch dollars are base funding for faculty salaries, there is a built-in evaluation mechanism through annual reviews of overall performance, research productivity and the leveraging of additional research dollars. In addition, many of the research projects have an evaluative element that is required by state and federal-level funding sources that provides documentation related to project assumptions, goals and outcomes. This information is used to determine the overall success of the research initiatives; their contribution to providing practical, real-world solutions and resources to address challenges and problems; and whether continuation funding and/or new dollars are appropriate and necessary as funds are available.

Other examples of MSU Extension evaluation results in this area not previously described include:

Breakfast on the Farm

Issue (Who cares and Why)

The number of farmers in the U.S. declines eachyear, representing less than 2 percent of the country's population. This makes it difficult for farmers to personally interact with consumers, something that has become increasingly important when more than 70 percent of consumers admit to knowing very little about farming

What has been done?

Michigan State University Extension works to improve this disparity with programs like Breakfast on the Farm (BOTF). BOTF is an open door for the community to learn how its food is produced, and meet the local farmers who produce it.

Results

Since its debut in 2009, BOTF has hosted 37 on-farm events, giving 83,486 visitors an opportunity to enjoy a free, farm-fresh breakfast and learn more about agriculture and daily life on a modern farm. Since 2012, exit surveys show that participants have an increased level of trust for local farms after their visit. Other specific results were:·

- About 20% of households increased dairy product purchases.
- After visiting, 90% surveyed indicated they would talk to others about what they learned at BOTF.
- Since 2012, BOTF exit surveys show that participants have an increased level of trust that farmers will keep milk safe for consumers, and care for animals and the environment.

Another example is Get Engaged! A Guide to Getting Involved in Your Community

Issue (Who cares and Why)

Declining civic engagement has been well-documented and researched across the country. The summer 2017 Michigan Public Policy Survey conducted by the Center for Local, State,

and Urban Policy found that most local leaders in Michigan believe their jurisdictions offer "a great deal" of opportunities for citizen engagement, but report low and declining levels of engagement. Grand Traverse County approached MSU Extension in early 2017 inquiring about education on civic engagement and community leadership.

What has been done?

MSU Extension's Government and Public Policy and Leadership and Community Engagement teams developed "Get Engaged! A Guide to Getting Involved in Your Community" and piloted this program in Grand Traverse County in October 2017. This program sought to:

- Educate residents about local government
- Help participants understand the local government finance structure and process
- Teach residents their rights and responsibilities as community members
- Give participants the tools to communicate effectively on public issues
- Increase participants confidence in their ability to engage in local decision-making processes

Participants took part in seven 3-hour sessions including lectures, class discussion, presentations by local elected officials and county government staff, a facilitated planning process, and a county government budget simulation.

Results

- 88% reported a strong knowledge of how local government works, compared with 39% in the pre-program survey
- 73% reported understanding local government finance, compared with 15% before the program
- 94% were confident in knowing their rights and responsibilities as citizens, compared to 64% before the program
- 50% said they were very confident in their ability to communicate effectively on issues of conflict compared to 32% prior
- In the pre-program survey, 18% said they were not at all confident they could make a difference in their community. **In the post-program survey that number had dropped to 0.**

Public Value

Educating community members on how to engage in local decision-making processes, while giving them a foundational knowledge of how local governments work empowers them to work collaboratively on complex issues in their communities and be productive and engaged members of their community. This helps promote stability, strong neighborhoods, and safe communities.

Another example is Dining with Diabetes

Issue (Who cares and Why)

Chronic diseases are among the most prevalent, costly, and preventable of all health issues. Over 60% of Michigan adults have at least one chronic condition, which results in spending 75 cents of every health care dollar to treat these conditions. Over 95% of Michigan adults report engaging in unhealthy behaviors that increase their risk of developing a chronic disease (MDCH 2014). According to the World Health Organization, if the major modifiable risk factors (i.e., inadequate physical activity, poor diet, and smoking) were eliminated, at least 80% of heart disease, stroke, type 2 diabetes, and 40% of cancers would be prevented.

What has been done?

MSUE developed Dining with Diabetes that is a five-session course designed for people at risk of diabetes or who have diabetes, as well as their family members. Through Dining with Diabetes participants learn how to prepare healthy meals using less fat, how to make meals using less sodium and sugar without reducing flavor and enjoyment, the causes of

diabetes, tools for managing diabetes, and the importance of diet and exercise in managing diabetes. The program offers opportunities to sample a variety of healthy foods and take home recipes to further encourage behavior change.

Results

In 2017, **246 participants** from **19 counties** participated in the Dining with Diabetes program taught by 9 instructors. Pre- and post- program evaluation data was voluntarily returned. Analyses of the evaluation data found as a result of participating in the Dining with Diabetes program:

- 76% fit exercise into their daily routine
- 56% exercise continuously for at least 30 minutes at least three times a week
- 63% participate in physical activity such as walking on a daily basis
- 81% cook more at home
- 94% eat smaller proportions
- 77% are using recipes provided by the program

Another example is Get Engaged! A Guide to Getting Involved in Your Community

Issue (Who cares and Why)

In recent years, much attention has been paid to the detrimental effects on long-term health due to adverse childhood experiences or ACEs. A landmark study done in 1998 by Kaiser Permanente found a strong relationship between the exposure to abuse or household dysfunction during childhood (ACEs) and multiple risk factors for many leading causes of death in adults. Resilience is a combination of protective factors of both individual characteristics and social environments. It includes the following:

- Knowing how to manage stress and use tools to help you cope
- Being able to step away from your emotions when things get hard
- Coming back after bad experiences and helping your kids do the same
- Stable, caring relationships and positive parenting help build resilience

What has been done?

MSUE implemented Nurturing Families that is an evidence-based program authored by Stephen J. Bavolek. There are 10 workshops in the Community Based Education Program series used by MSU Extension. Lessons include worksheets, handouts, interactive activities and discussion. The overall goal of this program is to reduce child abuse and neglect through education on the philosophy and skills of nurturing and increasing family protective factors. Topics include understanding feelings, alternatives to spanking, communicating with respect, praising children, building self-worth, infant and toddler development, learning positive ways to deal with stress, understanding and developing family rules and ways to enhance brain development.

Results

During 2017 there **90 series** were taught to **564 participants** in **10 counties** (Wayne, Kent, Washtenaw, Monroe, Ottawa, Delta, Gogebic, Otsego, Hillsdale, Ingham), facilitated by **8 Michigan State University Extension staff**.

- 51% Improvement in **Family Functioning and Resiliency** - Having adaptive skills and strategies to persevere in times of crisis. Family's ability to openly share positive and negative experiences and mobilize to accept, solve and manage problems.
- 35% Improvement in **Social and Emotional Support** - Perceived informal support (from family, friends and neighbors) that helps provide for emotional needs.
- 38% Improvement in **Concrete Support** - Perceived access to tangible goods and

services to help families cope with stress, particularly in times of crisis or intensified need.

- 37% Improvement in **Nurturing and Attachment** - The emotional tie along with a pattern of positive interaction between the parent and the child that develops over time

Knowledge of Child Development is reported on five individual items that show and understanding and utilizing effective child management techniques and having age appropriate expectations for children's abilities.

- 44% improvement on: I know what to do as a parent.
- 32% improvement on: I know how knowledge on how to help my child learn.
- 34% improvement on: I realize my child does not misbehave just to upset me.
- 23% improvement on: I praise my child when they behave.
- 23% improvement on: When I discipline my child, I don't lose control.

Key Items of Evaluation

AgBioResearch:
Serving Communities (Spring/Summer 2017, Futures Magazine) **https://tinyurl.com/y97r2x28**
Ensuring the long-term sustainability of Michigan's water resources goes beyond the computer screen, however. For water conservation practices to be effective, they have to go beyond merely reducing pollution and preventing the overuse of water resources - they have to be practical for farmers.
Stephen Gasteyer, associate professor in the MSU Department of Sociology, worked closely with Bartholic and the IWR research team to understand how farmers view water conservation practices and help them make data-driven decisions.
"If you look at a map of pollution in a watershed map, you'll see pollution isn't evenly distributed," Gasteyer said. "Chemical runoff tends to be concentrated in very specific areas, and my efforts focus on identifying why these problem areas occur and ways we can help farmers reduce them."
Though several government agencies and research groups were looking at various parts of this issue, Bartholic said none of them were approaching it holistically. With assistance from Gasteyer, Bartholic worked to change that.
After a year of discussions with Michigan farmers about water conservation, the IWR identified three issues:
The majority of farmers are willing to make improvements to their landscape, including using best practices to reduce water withdrawal and chemical runoffs. Implementation, however, must make financial sense.
A variety of best practices for water conservation are needed because the practice that works on one farm may not work on another mere miles away.
More knowledge is needed on why a minority of farmers do not implement water conservation practices and ways to encourage them to do so.
In pursuit of these issues, Gasteyer and his team of graduate student researchers took to the field, visiting individual farms and holding community meetings to learn more about what practices were working.
They wanted to know why some farmers were interested in water conservation and why others were not. Their work focused on the River Raisin watershed in southeastern Michigan near the Ohio border, where the team had established contacts among both the agricultural and conservation communities.
"It's all about communicating with farmers, one way or another," Gasteyer said. "It's about finding ways to build trust and understand one another, then finding ways you can both achieve your goals together."
"It's increasingly clear that farmers want to work with researchers to better their land, rather

than have us or government agencies hand down edicts without a full understanding of their landscape," Gasteyer said. "Most of them are really receptive and want to have an operation that's as efficient and conservative as possible."

MSU Extension:

Youth

219, 468 unduplicated youth were served by MSUE Extension in 2017
Specific to this area:
- 80,965 youth involved in Health
- 40,161 youth involved in Leadership and Personal Development
- 32,628 youth involved in Communication and Expressive Art
- 6,941 youth involved in Civic Engagement
- 8,653 youth involved in Community and Volunteer service
- 7,908 youth involved in Technology and Engineering
- 5,331 youth involved in Personal Safety

Adults

- 44,361 adults were trained in Nutrition and Physical Exercise
- 12,835 adults volunteered for 4-H
- 12,246 adults were educated at Public Events that included Breakfast on the Farm, Agriculture Literacy, Consumer Education, Food Systems, and more
- 9,773 adults were trained in Youth Development
- 5,363 adults were trained in Government and Public Policy
- 3,163 adults were trained in Finance/Homeownership
- 2,314 adults were trained in Disease Prevention and Management

V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

Soil, Water and Natural Resources

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
101	Appraisal of Soil Resources	0%		100%	
102	Soil, Plant, Water, Nutrient Relationships	35%		0%	
111	Conservation and Efficient Use of Water	10%		0%	
112	Watershed Protection and Management	5%		0%	
123	Management and Sustainability of Forest Resources	5%		0%	
131	Alternative Uses of Land	10%		0%	
133	Pollution Prevention and Mitigation	5%		0%	
216	Integrated Pest Management Systems	20%		0%	
806	Youth Development	10%		0%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	15.2	0.0	11.5	0.0
Actual Paid	13.4	0.0	16.0	0.0
Actual Volunteer	24.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
657252	0	1161267	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
657252	0	1213275	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	7482823	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Research programs and Extension activities to:

- Develop new land use models for Michigan communities.
- Offer education to planners, elected officials and citizens on how these new models will reduce sprawl and ensure that the desirable outcomes will become reality.
- Create new remediation strategies to clean up polluted soil and water. These strategies will be environmentally friendly, economically feasible and easy to implement with proper training.
- Discover new knowledge about the composition, organization and fluctuations of microbial populations in the soils.
- Develop a user-friendly computer program for nutrient management for Michigan crop and livestock producers to improve the management of fertilizer and manure nutrients on cropland to protect water resources and boost crop productivity.
- Develop management techniques for potato and vegetable growers that includes cover crops.
- Develop new nitrogen application recommendations for turf managers.
- Develop a management system for Michigan inland lakes that does not involve sampling the lakes.
- Develop Total Maximum Daily Load (TMDL) assessment tools for evaluation of Michigan watersheds.
- Determine how wildlife responds to ecosystem management decisions in forest and agricultural systems
- •Develop fish population/community computer models for species important to Michigan. These models will be used to evaluate different fishery management strategies.
- Develop web-based tools and models for natural resources managers so knowledge can be shared quickly and easily.
- Develop computer models to assess how habitat management affects species important to Michigan, including white-tailed deer, salmon, trout and perch.
- Promote and support value-added processing of forest products, including wood products, biofuels, maple syrup and other nontimber products.
- Identify, prevent and control exotic invasive pests and diseases of forests.
- Conduct educational programs to help farmers improve nutrient management and other practices to maintain and improve quality of groundwater and surface water.
- Conduct educational programs with riparians and lake users to enhance their understanding of watershed management and inland lakes water quality issues.
- Work with state agencies and local communities to encourage protection of community groundwater supplies through wellhead protection programs.
- Educate and train health officials, consultants, engineers and riparians to improve onsite and decentralized wastewater treatment and design.

2. Brief description of the target audience

Michigan farmers, natural resource managers, private citizens, agriculture and natural resources industry representatives, state agencies, riparians and foresters.

3. How was eXtension used?

MSU Extension continues to utilize eXtension as one of the primary multi-state activities that involve contributing to Communities of Practice, responding to Ask an Expert questions, and contributing to innovation projects. One example in this area was:The North Central Region Water Network "Impact 2020 Design for Success Workshop" collaborated with eXtension. In addition, this area has one of the highest requests for Ask an Expert.

V(E). Planned Program (Outputs)

1. Standard output measures

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	18978	56934	14070	14070

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2017
Actual:	5

Patents listed

MICL02340, Soil Water Retention Technologies that Maximize Production and Reduce Contamination of Groundwater (SN 15/460,196), MICL02373 Development of Biodegradable and Compostable Nanocomposites (SNs 15/230,128, 62/510,563); MICL01821, Microbial Ecology and Genomics of Soil Bacteria (SN 15/417,522); MICL02478, Electrochemical Approaches for Energy Harvesting from Waste and for Pollution Mitigation (SN 15/589,950)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	0	59	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research programs on soil, water and natural resources.

Year	Actual
2017	52

Output #2

Output Measure

- Number of adult participants trained in soil, plant, water and nutrient relationships.

Year	Actual
2017	9219

Output #3

Output Measure

- Number of adult participants trained in how human activities impact on ecosystems.

Year	Actual
2017	9759

Output #4

Output Measure

- Number of youth participants trained in how human activities impact on ecosystems.

Year	Actual
2017	14070

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of research programs to discover new knowledge about the composition, organization and fluctuations of microbial populations in the soils.
2	Number of adult participants with increased knowledge of how human activities impact ecosystem.
3	Number of research programs to determine how wildlife responds to ecosystem management decisions in natural resource and agricultural systems.
4	Number of adult participants with increased knowledge of soil, plant, water and nutrient relationships.
5	Number of research programs that deal with fish population dynamics and the management of Great Lakes fisheries.
6	Number of research programs that deal with the security, stewardship and management of Michigan's water resources.
7	Number of research programs that analyze key soil characteristics to better assess their agricultural and environmental contribution, including crop yield.
8	Number of research programs that explore the occurrence, transport and fate/effect of organic contaminants, chemicals, pesticides, pharmaceuticals and particulates in soils.
9	Number of research programs to develop new land use models for Michigan communities.
10	Number of youth participants with increase knowledge on how human activities impact on ecosystems.

Outcome #1

1. Outcome Measures

Number of research programs to discover new knowledge about the composition, organization and fluctuations of microbial populations in the soils.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Soil harbors the greatest undiscovered microbial diversity. This diversity recycles Earth's nutrients and helps maintain our atmosphere. This research is aimed at discovering some of that diversity, especially novel microbes that degrade chlorinated pollutants such as PCBs, chlorinated solvents and pesticides; microbes that have unique freezing protection mechanisms, and microbes that affect nitrogen availability for plant growth.

What has been done
Research to: understand temporal and spatial control of gene expression during development of soil bacteria; and develop new technologies to control soil-borne diseases.

Results
Progress towards the long-term goal of this project, which is to develop, release and utilize a comprehensive suite of innovative software applications named CMEIAS (Center for Microbial Ecology Image Analysis System) designed to strengthen microscopy-based approaches for understanding microbial ecology. These activities include a continuation of research to develop CMEIAS software and utilize this computing technology to quantify and discriminate the ecology of microorganisms associated with agriculturally important crop plants and in freshwater ecosystems.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
102	Soil, Plant, Water, Nutrient Relationships

Outcome #2

1. Outcome Measures

Number of adult participants with increased knowledge of how human activities impact ecosystem.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	8588

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example in this area is the impact of septic tanks on water shed. Data has shown from point of sale follow up data estmates that at least 10% of septic sytems checked through these programs are in some level of malfunction or failure. With over 1.2 million septic systems in Michigan, that can have be a significant negative on both surface and ground water.

What has been done
Homeowner septic system education programs have been offered since 2012 by MSUE in partnership with local health departments, local municipalities and other organizations and consultant. MSUE offered 5 in person workshops in southeast Michigan in 2017. Over 100 residents participated in these programs.
In addition the 2016 statewide webinar was edited to add to the MSUE Septic Education web page as another education resource for residents. As of December 2017, 371 visits were made to the webinar on this page.

Results
Annual follow up survey was sent out to all participants to assess behavior changes as a result of their program participation. Results found:

For the Workshop - 60% made changes after workshop that included:
- 47% spaced out laundry thru out week
- 47% had tank pumped
- 35% adopted water conservation practices
- 29% had system checked by professional

For the Webinar - 70% made changes after webinar that included:

- 54% spaced out laundry thru out week
- 38% stopped putting grease, oils, fats into system
- 31% had tank pumped
- 27% reduce water use in home
- 27% reduce use of garbage disposal

The majority of the participants understood the connections between individual septic system and surface and groundwater quality. Nearly three quarters of survey respondents shared program information with others creating a ripple effect.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
123	Management and Sustainability of Forest Resources
131	Alternative Uses of Land

Outcome #3

1. Outcome Measures

Number of research programs to determine how wildlife responds to ecosystem management decisions in natural resource and agricultural systems.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
State wildlife agencies regulate harvest of game species to meet dual objectives of allowing recreational take while ensuring sustainability of populations. Compliance with harvest regulations and cooperation with accurate reporting of effort and harvest success are important for meeting these objectives. Adjustments in harvest regulations (e.g., annual bag limits, season length) and reporting and registration requirements for furbearers including bobcat, fisher, American marten, and otter are common in Michigan. Advancements in statistical modeling of age-at-harvest data now allow for furbearer population abundance estimates, which were historically difficult to obtain. Recent population modeling of marten and fisher abundance in the Upper Peninsula (UP) of

Michigan indicate substantial population declines over the past decade. These declines have been attributed to decreased survival of adults of both species. Managers possess long-term harvest datasets however, little is known about reliability of these reports and other mortality sources including illegal take by furharvesters. Unlike with many other North American game species, the existence of a legal commercial market for fur means harvest of furbearers can be partially motivated by economic gain. Participation in trapping is known to increase with fur prices, which may also increase motivation for users to engage in illegal harvest. Trappers may exceed restrictive bag limits by making use of licenses purchased by nontrappers (with success and potentially effort then being falsely reported by individuals that did not actually trap), take furbearers within closed areas or during closed seasons (with harvest location and dates then being falsely reported). A lack of compliance with legal harvest rules may not only place populations at risk of overexploitation, but also promote generation of falsified data, interfering with assessment of harvest regulation and evaluation of impacts of regulated harvest on population dynamics and viability.

What has been done
Research to: understand the mechanisms of wildlife dynamics on landscape mosaics; develop a better understanding of wildlife-habitat relationships as influenced by natural and managed wildlife habitat disturbances; and uncover systematically informative morphological and molecular characteristics related to arthropods in order to revise classifications and test evolutionary hypotheses; understand wildlife responses to habitat management; and improve wildlife management.

Results
The goal of one project is to improve management approaches for conserving biodiversity through understanding of the factors that significantly affect furbearer management in regards to four limited take species in Michigan: bobcat, fisher, American marten and river otter. The focus will be to increase knowledge and understanding of the extent and nature of illegal take to inform more effective furbearer management in Michigan, particularly wildlife programs and policies. To this end, interviews have been completed and preparations are ongoing for participatory risk mapping.

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources

Outcome #4

1. Outcome Measures

Number of adult participants with increased knowledge of soil, plant, water and nutrient relationships.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	8112

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Soil testing is a recommended practice to avoid over fertilization. Applying the correct amount of fertilizer can save money and protect Michigan?s water resources. In additions, there are concerns with contamination from lead or other materials in the soil, which testing can also provide valuable information for decision making.

What has been done
MSU Soil and Plant Nutrient Laboratory (SPNL) operates as an integral part of Michigan State University providing support to teaching, research and extension programs. The SPNL offers a variety of analytical services on samples of soil, greenhouse growth media, composts, plant tissue, water and other materials related to the growing of plants (crops) received from commercial and part-time farmers, greenhouse operations, golf courses, homeowners, consultants, researchers, and others.

Many county extension operations use soil and plant tissue testing as the foundation for extension programs with their various clientele groups. Researchers in many departments within MSU and other universities have the SPNL analyze soil, plant and water samples as part of their research programs.

The SPNL reaches out to the general public through educational displays and presentations at expositions, conferences and meetings of organizations. Numerous groups tour the SPNL facilities throughout the year. Educational presentations and tours of the SPNL are part of five courses taught in the department of Horticulture and Department of Plant, Soil and Microbial Sciences.

Managing an overwhelming number homeowner soil tests interpretations led researchers and educators to develop an online soil test interpretation website and an accompany self-mailer for soil samples. The website was launched in 2008 with the soil test self-mailer (STSM) piloted in 2011. Under the guidance of consumer horticulture team members, these tools worked in tandem for five years with continued development and improvements made as needed. In 2017, interest by other states to purchase the software led to re-engagement of the development team members.

Results
To further assess needs, the team developed and implemented a survey to determine the value of the MSU Soil Testing Services for gardeners and obtain clientele input on improvements.

The survey was sent to 6,050 homeowner clientele who had their soil tested between 2015 and 2017. There was a 25% response rate (n=1,518)

Results:
What clients learned:
- 87% learned the importance of fertilizers to keep their plants / lawn healthy
- 84% learned how to select the right fertilizer according to their soil test recommendations
- 76% learned how to apply fertilizers according to their soil test recommendations
- 75% learned the role organic matter plays in soil health
- 79% learned the role soil pH plays in plant nutrition
- 73% learned the potential negative environmental impacts that fertilizers can have if improperly applied.

What clients did as a result:
- 80% shared or plan to share knowledge gained from having their soil tested
- 48% modified the amount of fertilizer applied
- 48% only applied fertilizer according to what the plant needs
- 7% live near a body of water and modified their use of fertilizers

Assessment of service:
- 92% - received results in a timely manner
- 91% - recommended the MSU Soil Testing Service to others

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships

Outcome #5

1. Outcome Measures

Number of research programs that deal with fish population dynamics and the management of Great Lakes fisheries.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	7

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Ecosystem changes due to global issues such as invasive species, land use change, and climate change have stretched the abilities of managers and policy makers to devise adaptive governance systems that ensure the sustainability of fish stocks and the integrity of the ecosystems. Without healthy fisheries and their ecosystems, important sources of recreation,

economic benefits, and nutrition are at risk. To achieve healthy and productive fisheries, we must assure the integrity of our freshwater ecosystems.

What has been done
Research to: investigate areas of uncertainty for Great Lakes fishery management, particularly sea lamprey control and salmon stocking; determine how fish population dynamics are affected by the physical, chemical and biological environment; investigate how human activities bring about changes in aquatic habitats; develop models capable of predicting response of fish to habitat alteration; investigate the environmental effects on fish genetic diversity.

Results
In one study, Lake Erie, walleye (Sander vitreus) fishery recruitment is controlled by physical and biological processes acting on early life history stages; however, the impacts of recent, recurring cyanobacterial (Microcystis aeruginosa) blooms on fishery ecosystem productivity are largely unknown. Harmful algal blooms (HABs) did not have a significant impact on walleye year class strength, but they did impact the distribution of YOY forage fishes and larval fishes in the western basin, contributing to a spatial mismatch between walleye and their prey. In particular, HABs were associated with a decrease in the relative abundance and size of larval clupeids, the preferred prey of walleye. However, warm, nutrient-rich conditions that favor HAB formation also promoted zooplankton production. Therefore, it appears HABs directly impact larval and planktivorous fishes, rather than indirectly decreasing their abundance by limiting the availability of zooplankton prey. These results suggest HABs have positive and negative, direct and indirect effects on fishery ecosystems. Continued monitoring of multiple trophic levels is needed in an adaptive, ecosystem-based management approach to ensure sustainable harvest and the wellbeing of coastal communities in this re-eutrophied system.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management

Outcome #6

1. Outcome Measures

Number of research programs that deal with the security, stewardship and management of Michigan's water resources.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	13

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
With an ever increasing global population and demand for food, stresses on sustainable water quality and availability will likely intensify resulting in water issues emanating in part from agricultural production practices. If these practices do not sufficiently connect in harmony with the natural system through a better understanding of system functions, particularly relative to water quality and quantity, government organizations at numerous levels may place greater constraints on agricultural operations. Such constraints will address certain popular issues and critically important ones such as water quality and quantity, yet these constraints may greatly restrict the flexibility, profit margin, and sustainability of the agricultural systems in many parts of the state and nation.

What has been done
Research to: enhance the current water resources management structure through the ecosystems approach, development of a system to help create sustainable water resource management, understand how anthropogenic actions can affect food web structure and function, address critical questions that have relevance to specific problems in Michigan inland lake and Great Lakes integrity; help develop dynamic, interactive computer interfaces in resource-based recreation management; construct and evaluate a knowledge management system in resource-based recreation management; develop a landscape-based ecosystem management framework that integrates landscape ecology with natural resource policy and management; determine why sport fish populations, fish assemblages and lake food webs, and their response to perturbation vary among lakes; determine if pheromones can be used to control sea lamprey in streams, with a view to developing a viable new control strategy; to improve design of engineered phytoecosystems for treatment of wastewaters and stormwaters; assess the value of ecosystem services from inland waterways; and understand sustainable water use of both natural and agriculture systems.

Results
We are in the 3rd and final year of a USDA-NIFA funded grant - An Integrative Decision Support System for Managing Water Resources Under Increased Climate Variability. During the reporting period modeling efforts were completed that incorporated various climate scenarios, and the decision support system - eWaterWays - was finalized. There were three team staff meetings held during the reporting period to allow a discussion of the research efforts and to provide status updates. The final team meeting was held in 2016.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation

Outcome #7

1. Outcome Measures

Number of research programs that analyze key soil characteristics to better assess their agricultural and environmental contribution, including crop yield.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	6

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Soils simply do not contain adequate nutrients to support the sheer quantity of plant growth required from today's agricultural production systems. Sufficient nutrients supplied from either organic or inorganic sources are required to maximize crop growth and attain crop yields able to support the world's population. Globally, nitrogen fertilizer usage has increased 10-fold since the mid-20th century resulting in both positive and negative repercussions. Although agricultural and foreign policy changes have contributed to the rising costs of natural gas and urea over the last 5-7 years, the escalating price of crude oil has primarily driven the hike in fertilizer prices. Even though commodity prices have correspondingly increased 60% over the last two years, input costs are projected to remain on an upward climb. This combination of factors has pushed fertilizer costs to a tipping point where producers are carefully reconsidering their fertilizer sources and rates based on crop response and price per unit of nutrient. Simultaneous to the fertilizer and crop price increases, yields across many crops have substantially increased over the last decade and have resulted in increased nutrient requirements. Developing efficient soil and nutrient management practices that maximize the genetic potential of Michigan cropping systems, improves the profitability for Michigan producers, and promotes nutrient stewardship amongst all production systems will be essential to the sustainable management of our natural resources.

What has been done
Research to: study herbivore suppression of cyanobacteria and total phytoplankton biomass; effectiveness of nitrogen rates on soil quality and plant nutrition; study the characteristics of high content soil blends used in athletic fields and golf putting greens and how the properties of these soils change with time and use; and to explore diversification with cover crops to enhance nutrient cycling efficiency and rhizosphere traits for resilient, productive row crop systems.

Results

We expanded assessments of landscape spatial patterns in factors affecting soil carbon and nitrogen processes under contrasting agricultural managements, with specific focus on cover crops. Using additional support from Project GREEEN and from CRDF Global fund, we have established additional three experimental sites in Ukraine. Both in MI and Ukraine experimental sites we are collecting above and below ground biomass and information on performance of main and cover crops. Preliminary results will be reported at the annual meeting of SSA/ASA/CSSA societies in Oct. 2017.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
102	Soil, Plant, Water, Nutrient Relationships
111	Conservation and Efficient Use of Water
133	Pollution Prevention and Mitigation

Outcome #8

1. Outcome Measures

Number of research programs that explore the occurrence, transport and fate/effect of organic contaminants, chemicals, pesticides, pharmaceuticals and particulates in soils.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	8

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Michigan's 37 million acres of land support the plants and animals that provide our shelter, food and fiber. The land provides us with minerals and foods for our industry and our businesses. At the same time, human activities are generating and releasing large amounts of pollutants -- including pesticides, antibiotics and dioxins, and other industrial emissions -- that may end up in the soil. Research to investigate the fate and effect of these pollutants is critical to sustaining soil viability and health, and minimizing consequences to human health.

What has been done

Research to: investigate the transport of a group of engineered nanomaterials in the soil and water environments and develop an understanding of their interactions with other elements; evaluate the occurrence and human health risks of historic pesticide contamination of agricultural soils; understand the mechanisms by which chronic estrogen exposure brings about reproductive failure; determine the mechanistic functions and contributions of soil humus and clays to the immobilization of pesticides and POPs found in soils; evaluate the occurrence of antibiotics in animal farms and their mobility; to control and convert rural waste to resources; and to understand adaption for ecosystem responses.

Results
Analysis has been completed to better estimate the cost of providing ecosystem services on agricultural lands. We find that the marginal costs of mitigating greenhouse gas emissions in California Central Valley agricultural sector appear to be cost-effective relative to traditionally capped energy sectors.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
102	Soil, Plant, Water, Nutrient Relationships
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation
216	Integrated Pest Management Systems

Outcome #9

1. Outcome Measures

Number of research programs to develop new land use models for Michigan communities.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	6

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

What we do to our land is intimately tied to our drinking water quality, wildlife habitat, potential for flooding, our recreational open space and tourism, and many other quality of life issues. For example, urbanization of the rural landscape is claiming some of the country's richest farmland and creating challenges for areas where rural and urban interests collide. Some recipients indicate the, by 2020, farmers will only have enough land to meet the nation's domestic food needs.

What has been done
Research to: better understand how regional and continental processes affect local processes; increase management capacities among agencies to better integrate biological and human dimensions of management in dealing with wicked problems, such as wildlife health; and to help develop sustainable agro-ecosystems that protect public health, environmental quality and promote efficient and profitable resource use.

Results
Bio-based, biodegradable and compostable polymers such as PLA has gained great attention due to its lower environmental footprint. PLA could become a solution to "white-pollution" due to its lower environmental footprint and biodegradation profile. However, a major concern about PLA's end of life biodegradation scenario is its slow biodegradation rate in compost and ambient temperature. Additionally, novel biodegradable and compostable nanocomposite (BNC) incorporated with engineering nanoparticles (ENPs) like nanoclays, can improve polymer properties such as mechanical and barrier properties.
So, they are currently being produced. However, not much is known about their end of life scenario (EoL) specially biodegradation. We are working to increase this knowledge.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
112	Watershed Protection and Management
123	Management and Sustainability of Forest Resources
131	Alternative Uses of Land

Outcome #10

1. Outcome Measures

Number of youth participants with increase knowledge on how human activities impact on ecosystems.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	1238

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
There is a need to provide science literacy training locally and on a state and national level to help youth better understand their environment and the impact of human behaviors on ecosystems.

What has been done
MSUE partnered with the Iron Mountain Middle School for an Exploratory Education Spring 2017 that focused on environmental education and natural resources with hands on experiential activities.

Results
Evaluation results found:
- 84% responded that they feel more knowledgeable about natural resources

- 84% responded that they feel more sensitive toward the environment

- 66% said they are more knowledgeable about environmental issues

- 72% stated they would participate in a solution to an environmental problem

- 88% said they will change their behavior about actions that affect the environment

What difference did it make - public value?

This program has helped to create a greater awareness about the environment where these youth live. Additionally, some of the activities involve their input outside of school where their parents are incorporated into the activity developing an extension of learning with families.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
806	Youth Development

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

During the 2016-17 fiscal year, ABR and MSUE support many areas such as our Enviro-weather stations. To assist Michigan producers with pest, plant production and natural resource management decisions, Enviro-weather provides weather data from a network of stations located throughout the state. Enviro-weather data are shared with other weather groups across the region and are also used in college and university classrooms to teach students about topics such as weather, agriculture and pest management. Since the creation of the Enviro-weather program, data requests have grown from 96 on average per day to more than 450 in 2015.

Project GREEEN funds supported:

- Two tower stations added to the Enviro-weather network to provide real-time, cross-sectional temperature and wind information to fruit growers for monitoring low-level inversions and making decisions related to wind machine-based frost protection.
- Along with the two tower sites, three additional standard stations were added within the past year: Benona/Shelby, Michigan; Kewaunee, Wisconsin; and Grant, Michigan.
- Operational upgrades including strategic network and system modernization, as well as routine weather network maintenance.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

As Hatch dollars are base funding for faculty salaries, there is a built-in evaluation mechanism through annual reviews of overall performance, research productivity and the leveraging of additional research dollars. In addition, many of the research projects have an evaluative element that is required by state and federal-level funding sources that provides documentation related to project assumptions, goals and outcomes. This information is used to determine the overall success of the research initiatives; their contribution to providing practical, real-world solutions and resources to address challenges and problems; and whether continuation funding and/or new dollars are appropriate and necessary as funds are available.

Additional examples of programs and evaluation in this area for MSUE are:

4-H Training the Trainers for Natural Resoures

Issue (who cares and why)?

There is a need to provide science literacy training for 4-H PC staff so they have the

skills/knowledge to share this information at their county level with other professionals and volunteers

What has been done?

4-H supervisors implemented a workshop to help 4-H Program Coordinators in understanding science as it relates to the environment and build skills in teach youth about the environment and natural resources.

Results/Impact?

The evaluation results showed that:

- 53% of participants said they were quite a bit/A lot more knowledgeable about natural resources and the environment as compared to 38% before the workshop.
- 64% of participants responded they are more knowledgeable about science as compared to 46% prior to the workshop

What difference did it make - public value?

Comments made reflected participants valued the activities shared and they will use them in their local programming. This workshop can serve as a "spring board" to create larger networks of trained staff in environmental education and ultimately leading to more volunteer and youth opportunities.

Another example is:

Michigan Natural Features Inventory (MNFI)

Issue (who cares and why)?

Vernal pools are important for both wildlife habitat as well as for the ecosystem services they provide. Over 450 species of wildlife are known to use vernal pools; a few of those species depend on the pools for local population survival. The temporary nature of vernal pools allows them to act as filters for water that slowly seeps into the ground, recharging groundwater aquifers. In Michigan, information about the location and species use of individual pools is lacking. As a result, it is unclear if/how these unique ecosystems are impacted by people, and if regulations are necessary.

What has been done?

The Michigan Natural Features Inventory (MNFI) scientists created a citizen science based vernal pool monitoring program in an effort to increase the long term data available about vernal pools. A K12 based monitoring program, called the Vernal Pool Patrol, was also created to allow students to help in the effort and experience this fascinating outdoor classroom.

In 2017, 217 students were trained at vernal pools to conduct monitoring. Forty-six students participated in two consecutive spring field trips, where students collected data according to established scientific protocols, and had the chance to explore the ecosystem and its associated flora and fauna. The remaining 171 students participated in the fall field trip, and learned about the soil associated with vernal pools as well as how to recognize vernal pools locations according to local topography and landscape features (in the absence of water). Students also discussed the groundwater recharge functionality of vernal pools. These same 171 students will participate in spring 2018 field trips to complete the monitoring protocols.

Results/Impact?

Participating students understand that the quality of groundwater they drink and the water in which the recreate is related to groundwater infiltration as demonstrated by the temporary nature of vernal pools. Students also understand that many species of wildlife and invertebrates have an aquatic stage, and that survival rate is greater in a vernal pool than in a wetland ecosystem that supports a larger variety of predators. Lastly, students are aware that humans can have a negative or positive impact on the natural systems that surround them.

What difference did it make - public value?

Youth participants developed increased natural resource literacy creating a foundation for enhanced stewardship of natural resources as an adult. The youth may also share the information with the adults and help limit negative impacts on vernal pool or wetland ecosystems and other natural areas in their surroundings.

Key Items of Evaluation

MSU AgBioResearch

Helping scientists communicate, collaborate and achieve their goals

(https://tinyurl.com/ycxqu8hq)

For the past several years, major research funding agencies have started to emphasize the importance of assembling teams of experts drawn from a range of scientific disciplines. The advantages of this transdisciplinary approach are relatively unquestionable: the more specialists and experts from different areas of expertise, the greater the chance of formulating well-rounded, practical solutions.

This has been especially important in agriculture and natural resources, where topics such as climate change, biotechnology and food security constitute some of the most pressing, divisive and vital issues confronting us today. They are issues that require the attention of a multitude of scientific disciplines.

Bringing together a group of gifted, highly qualified researchers does not automatically translate to a cohesive team. The very diversity of experience and training that makes an interdisciplinary team an effective scientific asset can also lead to misunderstandings, inefficiencies and interpersonal conflict.

This is where the Toolbox Dialog Initiative (TDI), based at Michigan State University (MSU), comes in to play. MSU AgBioResearch philosopher Michael O'Rourke and MSU AgBioResearch research associate and program manager Stephanie Vasko lead scientific communication efforts locally, nationally and internationally, in collaboration with research partners at universities throughout the country.

The concept of TDI was derived 11 years ago to help graduate students work together in interdisciplinary teams as part of their scientific training. It uses tailored dialogue-based workshops to help teams enhance communication and collaborative capacity.

Restoring ecosystems through fire

Michigan State University scientists are working with U.S. Forest Service fire managers to improve methods to restore barrens.

Working alongside U.S. Forest Service fire managers in northern Wisconsin who are currently undertaking major projects to restore ecologically significant barrens ecosystems, Michigan State University scientists are improving methods to restore barrens.

Historically, periodic fires have voided barrens of shrubs, grasses and large trees that contribute to ecosystem succession, the process by which barrens transform into woodland. As human management of ecosystems has increased, fires have become less frequent and intense, causing succession to occur at a more rapid pace.

As the importance of fire in both woodland and barrens ecosystems has become more apparent, prescribed burns have emerged as a common tool for forest managers as they work to preserve and restore barrens. Researchers are in the middle of a three-year project to provide managers with more information on the impact of fire on various aspects of the environment, including soil, plant root systems and microbial life.

- **Barrens in Wisconsin have shrunk to one percent of their original area, threatening species.**
- **Prescribed burns often fail to heat the soil sufficiently to kill tree roots, allowing them to grow back.**
- **Conducting prescribed burns when fires would naturally occur may overcome the**

soil temperature issue and make them more effective.

Plotting a solution to prevent chronic wasting disease in Michigan wildlife

A disease of the nervous system exclusive to deer, elk, moose, caribou and other hoofed, antlered, ruminant mammals, chronic wasting disease (CWD) is similar to mad cow disease. The fatal sickness manifests in a range of behavioral issues, including listlessness, tremors, nervousness and increased thirst, as well as weight loss over time.

There is no known cure or vaccine for CWD, which is notoriously difficult to control. It spreads through direct fluid contact, and the structurally abnormal proteins are shed into the environment where the disease can persist for over a decade.

To control CWD outbreaks and prevent it from gaining a foothold in the state, Michigan State University wildlife researchers are using expertise in deer behavior and population dynamics to develop a predictive model identifying regions with dense deer populations and close proximity to states with CWD problems. This will give the Michigan Department of Natural Resources a valuable tool to fight the disease.

- Hunting, primarily deer hunting, annually contributes about $2 billion to Michigan's economy.
- Nine CWD cases have been identified in Michigan since the disease was first discovered in the state in 2015.
- Researchers in New York developed a similar tool in 2005, contributing to that state eliminating the disease by 2010.

MSU Extension

Youth

- 30,193 youth were trained in Biological Sciences
- 66,910 youth were trained in Environmental Education/Earth Sciences

Adults

- 4,337 adults were trained in natural resources
- 5,422 adults were trained through Sea Grant about the Great Lakes and water sheds
- 5,363 adults were trained about land use and public policy
- 978 producers/employees improved their awareness/knowledge/intend to implement new technology to improve water quality

V(A). Planned Program (Summary)

Program # 3

1. Name of the Planned Program

Plant Sciences

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms	0%		17%	
202	Plant Genetic Resources	0%		3%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants	0%		13%	
204	Plant Product Quality and Utility (Preharvest)	0%		5%	
205	Plant Management Systems	80%		10%	
206	Basic Plant Biology	0%		10%	
211	Insects, Mites, and Other Arthropods Affecting Plants	0%		12%	
212	Pathogens and Nematodes Affecting Plants	0%		12%	
215	Biological Control of Pests Affecting Plants	0%		5%	
216	Integrated Pest Management Systems	10%		13%	
806	Youth Development	10%		0%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	28.9	0.0	20.0	0.0
Actual Paid	36.1	0.0	28.0	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
1610097	0	2015784	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1610097	0	2106062	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	12989052	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Research programs to:

• Develop improved varieties of dry beans, tart and sweet cherries, potatoes, wheat, rice, soybeans, oats, barley, canola, turfgrass, apples, strawberries, blueberries, floriculture crops, chestnuts, vegetable crops, and conifers for Michigan growers.
• Continue to identify genes and genetic pathways that control plant response to environmental stresses and develop techniques to insert these pathways into at-risk plants.
• Identify and isolate novel genes, markers and genetic pathways that can benefit crops important to Michigan agriculture through higher yields, improved quality, and better insect and disease resistance.
• Identify and isolate novel genes, enzymes and other phytochemicals that may have benefits for human health and determine how these beneficial compounds can be made available to people.
• Develop integrated management strategies and provide education programs for producers of fruit, field, vegetable, floriculture, Christmas tree and forestry crops that use the lowest possible inputs of resources and improve yield and quality, while minimizing environmental effects, such as leaching and run-off.
• Develop cultural, management and insect and disease control strategies for crops that meet USDA certified organic standards so Michigan growers can take advantage of this growing market, if they choose to do so.
• Continue to develop biological controls for pest insects and diseases to minimize effects on the environment.
• Continue variety trials for crops important to Michigan, including wheat, corn, soybeans and forages.

Extension actitivities to:

• Conduct educational programs to help farm producers control weeds and more effectively manage high-cost fertilizer inputs while optimizing crop production.
• Develop plant disease prediction models.
• Conduct educational programs to help plant producers control disease caused by pathogens and nematodes and teach integrated pest management methods.
• Provide green industry professionals and homeowners with scientifically sound information to enable them to safely and effectively manage their turf, landscapes and gardens, improving efficiency of resources and controlling pests, while reducing pesticide and fertilizer use.
• Train Native American adults in sustainable agriculture.

2. Brief description of the target audience

Michigan growers (traditional and organic), commodity groups, agriculture and natural resources industry representatives (including herbicide, pesticide and insecticide suppliers), green industry/landscape/turf professionals, state agricultural agencies, Native American growers and the interested public.

3. How was eXtension used?

MSU Extension continues to utilize eXtension as one of the primary multi-state activities that involve contributing to Communities of Practice, responding to Ask an Expert questions, and contributing to innovation projects. One example in this area was: Agriculture and Natural Resources Cropping Systems Academy - Technology in Agriculture Group.

V(E). Planned Program (Outputs)

1. Standard output measures

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	15810	47430	5710	5710

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2017
Actual:	24

Patents listed

MICL02303, Improved Pretreatments and Enzymes for biomass Deconstruction (SN 15/437,359; 62/491,632); MICL02456 Genetic Improvement of Beans (Phaseolus vulgaris L.) for Yield, Pest Resistance, and Food Value (SN 201700006, 201700007, PV201700125); MICL02315, Exploring Sporulation and Spore Dispersal in Fungal Pathogens (SN 15/316,647); MICL02332,Genetic Improvement of Sour Cherry and Cherry Rootstocks (SN 15/330,731, 15/330,732, 15/330,737, 15/330,730, 15/330,734); MICL02166, Chemical Catalysis and Processing for Advanced Biofuels and Biochemicals (SN 15/359,735); MICL02357, Regulation of Lipid Metabolism in Plants and Algae (SN 15/487,063, 15/627,006, 62/479,599); MICL02462, Physiology and Biochemistry of Potato Tuber Disease Resistance (SN 15/502,553); MICL02368, Understanding Spatial and Temporal Variability of Crop Yield, Water and Nutrient Fluxes by Integrating Precision Agriculture with Crop Modeling (SN 15/612,442, 62/411,976); MICL02278, Molecular Genetics of Plant Defense Against Insects (SN 62/359,293, 62/379,773); MICL02384, Probing the Structural Basis of Cyanobacterial Photoprotection and CO2 Fixation (SN 62/378,979, 62/438,655); MICL02416, Root-Associated Fungi in Agriculture and Forestry (SN 62/458,236); MICL02347, Genetic Engineering of Oilseed Crops (SN BR102016015577-0)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	0	100	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research projects on plant sciences.

Year	Actual
2017	93

Output #2

Output Measure

- Number of adult participants trained in plant management systems.

Year	Actual
2017	15261

Output #3

Output Measure

- Number of youth participants trained in plant management systems.

Year	Actual
2017	5710

Output #4

Output Measure

- Number of adult participants trained in integrated pest management (IPM).

Year	Actual
2017	549

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of adult participants with increased knowledge of integrated pest management (IPM).
2	Number of research programs to develop insect and disease control and/or cultural and management strategies for organic crops.
3	Number of research programs to develop biological controls for pest insects and diseases to minimize any effects on the environment.
4	Number of research programs to develop integrated management strategies for fruit, field, vegetable, floriculture and forestry crops that use the lowest amounts of nutrients possible and improve yield and quality.
5	Number of research programs to identify and isolate novel genes, markers and genetic pathways that can benefit crops important to Michigan agriculture through higher yields, improved quality, and better insect and disease resistance.
6	Number of research programs to identify genes and genetic pathways that control plant response to environmental stresses and develop techniques to insert these pathways into at-risk plants.
7	Number of research programs to develop improved varieties of economically important crops for Michigan and the region.
8	Number of adult participants with increased knowledge of plant management systems.
9	Number of research programs to develop weed control methodologies, protocols and practices.
10	Number of research programs to develop controls for pathogens and nematodes affecting plants.
11	Number of research programs to develop production protocols and environmental and cultural strategies for the floriculture/nursery industry.
12	Number of research programs to develop more effective post-harvest protocols and practices to minimize loss and enhance quality.

Outcome #1

1. Outcome Measures

Number of adult participants with increased knowledge of integrated pest management (IPM).

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	529

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example of an issue in this area is the Drosophila suzukii (SWD) continues creating havoc in Michigan?s berry industry. In 2016, 100% of surveyed growers signaled SWD as the major source of economic losses at their farms (2016 SurveyMonkey, Garcia-Salazar et al). As of 2107, it remains as a major threat for Michigan?s berry industry, and the Michigan Blueberry Advisory Committee (MBBAC). Succeeding in managing the SWD requires in-depth training of growers on how to retool their current IPM programs to incorporate the SWD management. But this is not easy, especially for underserved minority growers with language barriers. IPM programs are a complex bundle of technologies requiring knowledge and management skills to be successfully applied, and its complexity prevents a rapid adoption of end-users (Fliegel, 1993; Wearing, 1988). In 2014, we asked growers about major obstacles for integrating SWD management into their current IPM programs. They indicated they needed more knowledge and understanding of how insecticide applications should be adjusted to account for pest behavior, crop conditions, insecticide chemistry and behavior on the crops, weather conditions and sprayer equipment. To meet growers? needs a Systems Approach to Pest Management curriculum-based IPM training program with classroom and experiential learning (Knobloch (2003) was developed and delivered to provide growers with the much needed knowledge.

What has been done
To meet growers' needs a Systems Approach to Pest Management curriculum-based IPM training program with classroom and experiential learning (Knobloch (2003) was developed and delivered to provide growers with the much needed knowledge. This new dimension added to the way we approach pest control problems is what we call "A Systems Approach for SWD Management". All lectures prepared in PowerPoint including training notes were extensively reviewed for relevance in content, clarity of wording, language and format to comply with MSU's web accessibility and English Language Proficiency (ELP) policy. Complex graphics were transformed into text explanations to be easily understood by web readers. For Spanish speakers, all PowerPoint

presentations and training notes were translated into Spanish to facilitate learning by growers with limited understanding of English.

Results

In 2017, the final evaluation via SurveyMonkey of 23 growers participating in the English training showed that despite a tremendous problem with the early arrival of the SWD and difficult weather conditions, growers succeeded in controlling the SWD. The number of insecticide applications conducted by trainees was on average 8 with 50% of the growers applying less than 8 insecticide applications during the season. Expenses for SWD control reported by trainees were on average $186/acre with 50% of the trainees reporting less than $250/acre. Regarding fruit losses, trainees reported on average 8.5% crop loses with 50% reporting less than 5%. In terms of economic value only 2 out of 14 reported economic loses of $250 or more/acre.

For the program offered to Hispanics the results were very similar. The after training evaluation of 31 participants indicated the applying what they learned in the program resulted in less insecticide applications than in previous years. On average they sprayed 6 times with 50% spraying less than 7 times. Pest control expenses reported were on average $180/acre. But 50% reported expenses lesser than $175/acre. Regarding to crop losses due to SWD fruit infestation they reported on average 10%. However, only 2 growers reported losses of 50 and 20% of the crop. The other four reported less than 5%. The amount in dollars lost to SWD was on average $239/acre. However, 4 out of seven reported $100/acre.

What difference did it make - public value?

The ability of growers, especially underserved and minority, berry growers to manage the SWD is hampered by their lack of knowledge and skills to use advanced IPM tools/strategies. And some growers that in 2016 & 2017 suffered extensive losses due to SWD are abandoning the industry. Since 2013, curriculum-based advanced SWD IPM training of growers is making the difference, and growers with access to MSUE IPM training are successfully reducing crop losses due to SWD. This positive trend needs to continue since it is crucial to maintain small fruit growers. livelihood and employment. That is especially important for underserved and minority, berry growers.

In a larger survey, results found:

-Participants who responded to a survey collectively managed 383,047 total field crop acres.

-$680,057 was projected in savings or added revenue to farms based on growers who indicated that they intend to implement 174 practice changes.

-Participants earned 603 Michigan Department of Agriculture and Rural Development pesticide applicator recertification credits.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
216	Integrated Pest Management Systems

Outcome #2

1. Outcome Measures

Number of research programs to develop insect and disease control and/or cultural and management strategies for organic crops.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Properly made compost can
be more than a soil amendment. Well made and amended compost can be a nutrient rich and biologically active root medium
that can reduce the use of peatmoss and other high energy soilless medium components such as perlite and vermiculite. A key
to using compost as a growing medium is developing recommendations and targets for chemical, physical and biological
properties necessary for container grown plants.

What has been done
Research to: increase the production and use of thermophilic compost and vermicompost as important tools
for organic and sustainable production and management of vegetable transplants and year round vegetable production and
marketing on rural and urban farms using greenhouses; studies addressing the behavior and ecology of crop, pest, and beneficial organisms were continued.

Results
Compost suitable for use as a growing medium in larger containers and for urban agriculture was produced (started June 15) using 2-year-old tree trimming wood chips, fall collected municipal leaves, baled straw and hay. The goal is produce substrates from locally available feedstocks without the use of sphagnum peat moss or coconut coir. The nutrient content of the substrate will be adjusted by blending with mature vermicompost and or addition of mined minerals. A marketing program for labeling and selling vermicompost in 4.5 gallon buckets was developed in cooperation with the MSU Recycling Center and Surplus store. Over 150 buckets were sold at

$25 each over the five-month period from May through September.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Pathogens and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems

Outcome #3

1. Outcome Measures

Number of research programs to develop biological controls for pest insects and diseases to minimize any effects on the environment.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	20

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Michigan is the leading producer of tree fruits in the Midwest, with over 72,000 acres of orchards. Tree fruits are a significant contributor to Michigan's economy with a 5-year average farm level value of $210 million annually. Among the key arthropodrelated challenges facing the Michigan tree fruit industries are the need for good pollination to maintain high yields and the threat from invasive and emerging pests. Furthermore, many factors acting together have heightened grower impetus to reduce chemical inputs and adopt alternative pest controls. Foremost among these is the need to reduce input costs in order to maintain economic viability. Concerns about pest resistance to insecticides and non-target impacts on natural enemies, new regulations governing pesticides, concerns about worker safety, and the public's interest in reducing the use of insecticides
provide further incentive for growers to increase reliance on reduced-risk pest management practices and to seek innovative ways to apply pest controls.

What has been done

Research to: develop and deliver Integrated Pest Management strategies for insects in Michigan vegetable crops; develop stable, sustainable management strategies for vegetable insect pests; determine the effectiveness of currently registered and experimental products for control of insect pests in small fruit crops; improve control of moth pests by pheromone disruption; increase knowledge about mode of actions or effects of pests and diseases on honey bees to achieve better control and to gain increased honey production and more effective pollination of agricultural crops; to develop biological and cultural tactics based on vegetation management; to increase knowledge about the plant defense genetics; and to use new pest controls for tree fruit production

Results

Monitoring programs for invasive and emerging pests have allowed growers to preserve extant tree fruit IPM programs and maintain environmental, consumer and worker safety. The value of tart cherry industry in Michigan is over $54 million and SWD has the potential to inflict substantial losses. A statewide survey revealed that the weekly MSU SWD trapping reports helped nearly all respondents (92%) make management decisions on their farms and a majority of respondents (76%) altered their insecticide program based on the SWD catch in traps. The project has played an important role in helping MI cherry
growers maintain their current IPM programs and avoid potentially tens of millions of dollars in damage by this pest. Maintaining a robust monitoring program in Michigan is essential to managing BMSB and avoiding the severe losses encountered elsewhere. Insecticides have been applied, in part based on project findings, to protect their crop from this pest. In the absence of good monitoring and management tools, future crop losses to BMSB could easily exceed $50 million in
Michigan. Our findings were published in a timely manner in the MSU Extension News, incorporated into the Michigan Fruit Pest Management Guide and used to prepare extension bulletins on SWD. BMSB and BSB management.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
212	Pathogens and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems

Outcome #4

1. Outcome Measures

Number of research programs to develop integrated management strategies for fruit, field, vegetable, floriculture and forestry crops that use the lowest amounts of nutrients possible and improve yield and quality.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	17

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Growers' livelihoods depend on production systems that are healthy and sustainable -- environmentally, ecologically and economically. Farmers in Michigan grow a diversity of crops second only to California, a state almost three times the size of Michigan. This world-class diversity necessitates a unique mixture of research and Extension programs to meet the needs of the state's growers, who produce more than 200 commercially grown commodities

What has been done
Research to: identify and characterize phloem-associated lipids and lipid-binding proteins and identify their role in plant development and pathogen defense response; optimize protocols for honeycrisp storage in air and in controlled atmospheres; utilize and integrate physiological, genetic and horticultural approaches for understanding and improving Great Lakes region high value fruit production; decrease reliance on conventional crop protection practices by using low environmental impact fungicides in combination with host resistance; and to improve row crop nitrogen management to optimize economic returns and reduce environmental impacts

Results
On one project we have significantly mitigated the impact of plant diseases in Michigan field crops and reduced unnecessary fungicide inputs. We have demonstrated that variety selection based on disease resistance is key to management of diseases, followed by judicious use of appropriate fungicides or biologicals. Unfortunately, pathogens are
constantly evolving, so the there is a continued need to screen crop varieties for resistance and fungicides/biologicals for their activity.

In another project, we identified swede midge as a new invasive pest of cole crops in Michigan, we have determined that the insect is present in commercial cole crop fields througout the state and that it is problematic for organic growers. Conventional growers are able to control this insect with their current management tools but organic growers suffer significant losses due to this pest.

4. Associated Knowledge Areas

KA Code	Knowledge Area
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

206 Basic Plant Biology

Outcome #5

1. Outcome Measures

Number of research programs to identify and isolate novel genes, markers and genetic pathways that can benefit crops important to Michigan agriculture through higher yields, improved quality, and better insect and disease resistance.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	17

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Plants are important sources of food, fiber, fuel and pharmaceuticals and as such developing a mechanistic understanding of plant growth, development and biochemistry will facilitate the development of new crop varieties with improved production characteristics.

What has been done
Research to: identify and characterize phloem-associated lipids and lipid-binding proteins and identify their role in plant development and pathogen defense response; optimize protocols for honeycrisp storage in air and in controlled atmospheres; utilize and integrate physiological, genetic and horticultural approaches for understanding and improving Great Lakes region high value fruit production; decrease reliance on conventional crop protection practices by using low environmental impact fungicides in combination with host resistance; and to improve row crop nitrogen management to optimize economic returns and reduce environmental impacts

Results
In one study, researchers explored non-parasitic bacteria and eukaryotic cells. Studies of E. coli have identified regulatory mechanisms that control the activity of DnaA, DnaB and DnaC at oriC in formation of the replisome that will duplicate the bacterial chromosome. The long-term objective of this research is to determine the molecular mechanism of replication initiation and its regulation using E. coli as a model system.

Chloroplasts arose from a free-living cyanobacterium and carry out the life-sustaining process of photosynthesis. Plastids also synthesize many compounds critical for plant growth and development, including lipids, amino acids and growth regulators. Specialized plastid types manufacture products of major agricultural importance, such as oil and starch. The propagation of

plastids occurs by division of pre-existing organelles. During leaf expansion this process results in a
developmentally programmed increase in chloroplast numbers and compartment size, maximizing photosynthetic productivity. Chloroplasts are also being increasingly exploited as factories for the production of biopharmaceuticals and other economically important products in plants, and our work is leading to ways of manipulating chloroplast size and shape, which may have utility in downstream bioengineering and agricultural applications. Therefore, our researchers studying the fundamentally critical process of chloroplast division in plants has potentially significant implications for agriculture and biotechnology in Michigan and around the world. They demonstrated through in vitro biochemical assays and ex vivo experiments in yeast that the FtsZA and FtsZB from the red alga Galdieria sulphuraria have properties similar to those of FtsZ2 and FtsZ1, respectively, in higher plants, i.e., that FtsZA provides the structural framework for the FtsZ ring while FtsZB promotes FtsZ ring remodeling and constuction by making FtsZ filaments more dynamic. Researchers prepared and published two papers on these findings.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
206	Basic Plant Biology
216	Integrated Pest Management Systems

Outcome #6

1. Outcome Measures

Number of research programs to identify genes and genetic pathways that control plant response to environmental stresses and develop techniques to insert these pathways into at-risk plants.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

As the world population increases and the demand for food and fuel relies more heavily on agricultural products, efficient methods of plant transformation will be required. Although conventional breeding will fulfill a part of this need, these techniques are limited to the gene pool of the species involved. In contrast, the tools of genetic engineering significantly expand the resources that can be used for variety improvement. Further, current transformation techniques are not applicable to all plant species.

What has been done
Research to: identify molecular markers for traits that are important in highbush blueberries; identify high-yielding oat, barley and canola cultivars for Michigan; provide guidance on disease control and crop health to the Christmas tree and chestnut industries; determine the biochemical mechanisms involved in turfgrass disease control; develop production methods to increase net returns to Michigan berry producers; elucidate molecular and biochemical mechanisms of plant resistance to arthropod herbivores; determination of how to better control for fungal and bacterial diseases of plants; and to develop improved analytical methods for the profiling of metabolites to assist in comprehensive measurements of biomarkers related to plant and animal health.

Results
Last year, we identified a source of resistance against the blueberry stem gall wasp, which is the top research priority set by the Michigan Blueberry Advisory Committee. The stem gall wasp significantly impacts the profitability of the blueberry industry in Michigan, and has steadily increased in severity over the past few years. During the last reporting period, we constructed a high-quality reference genome of the resistant genotype, and have planted and phenotyped a large genetic mapping population (Objective 1). This will permit us to more easily identify the underlying genes encoding resistance and to release superior, resisant cultivars against the stem gall wasp in future years. The reference genome will aslo serve useful to dissect the genetic architecture of other important traits to the blueberry industry.

On another project, accomplishments include discovery of genetic and biochemical factors that govern accumulation of specialized defense metabolites in tissues of the ornamental crop Petunia, elucidation of structures of key defense metabolites in Salpiglossis sinuata (a distant relative of tomato). Analytical methods developed in the Jones laboratory were also adapted by our collaborators to document an assortment of inflammatory and anti-inflammatory lipids in cow's milk. In addition, we performed measurements that supported efforts to engineer corn (maize) to contain higher levels of oils in vegetative tissues. In separate research, we documented that acetamide, a byproduct of ammonia treatment of biomass wastes considered to be a potential human carcinogen, is present at low part-per-billion concentrations in milk but is present at much higher levels (part-per-million) in roasted coffee.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
206	Basic Plant Biology
216	Integrated Pest Management Systems

Outcome #7

1. Outcome Measures

Number of research programs to develop improved varieties of economically important crops for Michigan and the region.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	15

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Michigan is the third most diverse agricultural production system in the U.S. Field crops are the most important commodity group in the state in terms of total crop acreage (at 6.5 million acres, 97% of the total), number of growers, and farm income, contributing over $4 billion in production value. Eight of the top ten commodities in Michigan are field crops, or dependent on field crops (livestock, egg production). Corn is the leading crop in the state in acreage (2.5 million acres) and cash value, followed by soybean (1.9 million acres). Unlike neighboring corn-belt states driven by corn and beans, Michigan grows a diversity of field crops, ranking first in several types of dry beans and fourth in sugarbeets. Other field crops include alfalfa, pasture, and other forages; small grains such as wheat, barley, oats, and rye. With the global demand for grain for direct consumption and livestock feed, as well as for biofuels, crop prices are at a high and field crop acreage is expanding in the state. Invasive species were and continue to be a major problem in the U.S. Michigan is a potential hot-spot for insect introductions, home to Great Lakes shipping ports, airports in Detroit and Chicago with non-stop flights to Asia, and a diverse crop base vulnerable to colonization by many species. Other invaders, foreign and native, are expanding in their range into Michigan. Thus producers are presented with new challenges from both foreign-invasive and native-invasive species that increase in pest status or range. Established and new insect invaders are now responsible for the majority of insect-caused
yield and quality loss in Michigan field crops, influencing pest management decisions, driving insecticide use and reducing
profitability. Tied in with invasive species is the issue of climate change. For some field crop insect pests, damage is getting worse and the damage period is growing longer during the season. A reality in field crop production is the use of biotechnology, specifically genetically modified crops with herbicide resistance or Bt insecticide toxin. According to the USDA Economic Research Service, 86% of the corn, and 91% of the soybean, acres in Michigan were transgenic in the 2012 planting season. Because universities have little role in the development of this technology, land grant entomologists are viewed as neutral observers and thus have an important

role to play in education and making public statements. A by-product of the introduction of Bt crops is overuse. Growers plant hybrids expressing insecticides that they don't need, exposing insect populations to traits year-after-year. This is antithetical to the principles of integrated pest management, because it increases the chance for resistance.

What has been done

Research to: identify the genes critical for the replication and repair of chloroplast DNA; understand the patterns of evolution of flora forms that contributes to the reproduction and persistence of Michigan plants; increase the environmental and economic sustainability of small fruit production through management of diseases in Michigan; understand the central plant metabolism and transport in plant systems well enough to rationally manage and engineer them for human benefit; develop a data-driven protocol for culture of juice grape cultivars as well as fruit plant canopies and management systems that fit into these advances to achieve maximum efficiency; and to discover genes that are co-expressed with genes known for amino acid biosynthetic and catabolic enzymes.

Results

The majoity of work in this project took place in soybean and corn production. In soybean, soybean aphid egg laying was not detected in overwintering sample sites (buckthorn in central Michigan) in fall 2016 and aphids on budding trees were not detected in spring of 2017. Natural field colonization by soybean aphid was detected in central Michigan and the Thumb in early June, but at extremely low levels. Aphids were subsequently collected from several locations, pooled, and caged in colonies on the MSU campus. These aphids were used to infest and screen experimental aphid-resistant germplasm developed by the MSU soybean breeding program. 2017 is the last field season for appreciable soybean aphid host plant resistance screening by MSU, because commercial companies have not shown an interest in marketing host plant resistance traits to deal with aphid outbreaks in the western corn belt, and aphid populations are extremely low in the east. We scouting multiple fields and alerted agribusinesses to report infestations as part of a region-wide project to identify parasitoid species and quantify parasitism of soybean aphid. Unfortunately, aphid numbers were so low that no parasitoids were found or collected for this project. Overall, soybean aphid populations in 2017 were the lowest this PI has seen since detection of this pest in North America in 2000. In contrast, stink bug numbers were the highest this PI has seen. As part of a regional project, fields in central and the Thumb of Michigan were sampled weekly for stink bug numbers and species.

Separate sets of sweeps were taken from the outer rows closest to potential stink bug sources (wheat, corn, treelines, fencerows, and structures) and from the center of the field. Sampling began on 17 July. Fields adjacent to wheat (which was just being harvested) or treelines had the highest number of stink bugs on the edge. By the first week of August, stink bugs started to colonize field centers and lay eggs. On 21 and 30 August, the last sampling dates, large numbers of stink bug nymphs were found in field centers. Stink bug species differed by location. Brown and green stink bugs predominated in fields adjacent to wheat, while brown marmorated stink bug was present in fields near treelines and structures. All sweep samples were saved and shipped to co-operators at the University of Minnesota for counting and processing; data is not yet available to report. For outreach (the main focus of this project) winter extension activities focused on reiterating best practices for soybean aphid management, specifically scouting and using a threshold of 250 aphids per plant. Eighteen Midwest soybean entomologists co-authored an article outlining the scientific basis for and utility of the current aphid threshold. In conjunction with publication of the article, an extension talk was developed to explain the impacts of spraying unnecessarily or too early for aphids in soybean, that is, aphid resistance and flaring of spider mite. Information was presented from the western US where aphid resistance is actually happening. This talk was delivered at 10 winter extension meetings to an estimated 700 growers and agribusiness employees.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems
206	Basic Plant Biology

Outcome #8

1. Outcome Measures

Number of adult participants with increased knowledge of plant management systems.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	12208

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Field crop farmers in St. Joseph County and surrounding counties rely in part on MSU Extension to provide them with the information they need to efficiently and profitably grow their crops. This meeting brought together several MSU Extension specialists and educators to deliver some of that needed information.

What has been done
A day-long meeting was held in St. Joseph County to deliver programming to field crop farmers and agribusiness employees that addressed a wide range of topics.

Results
In attendance were 28 farmers and agribusiness employees from 6 counties in Michigan (Berrien 1, Branch 1, Cass 2, Van Buren 1, Kalamazoo 8, St. Joseph 17). In addition to the MSUE specialists and educators, three farmers and agribusiness reps volunteered to participate on a panel sharing their experiences with using animal manure as a crop fertilizer. I conducted polls during the meeting to gauge participant interest in topics for future meetings. These results

helped to determine which topics to focus on for future programs. For example, 66% of attendees indicated they would like to attend meetings on "the intersection of livestock production, manure management, and the use of manure for crop fertilizer" and "learning the basics of various marketing tools and gaining experience in using them in a simulation-type environment". Polls were also included for each speaker's topic, and those results were sent to the respective speakers to help them achieve their outreach goals.

What difference did it make - public value? Those in attendance who responded to the survey indicated that they farm or directly impact 14,445 acres. When asked "Do you plan to change any aspect of your farm operation (or recommendations to producers) as a result of the information presented today?", 19 of 22 responded Yes. The respondents indicated that these changes would impact 7238 acres with an average of $11.25 per acre of increased revenue or decreased input costs, or a total of $81,427 increase among respondents.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems

Outcome #9

1. Outcome Measures

Number of research programs to develop weed control methodologies, protocols and practices.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Weeds are the primary pest problem in North American agricultural cropping systems. It is estimated that the total costs associated with losses, damage, and control of weeds in crops in the United States each year reaches $27 billion (Pimentel et al. 2005). Most management practices are directed at weeds once they have emerged in crop fields. However, weed management can be directed at different life history stages, reducing the number of weed seeds in the cropping systems by
impacting post-dispersal weed seed fate. When weed populations in time are modeled, seed

survival in the soil (the weed seed bank) is the number one factor influencing future weed infestations (Davis 2006; Ulrich et al. 2011). Integrated weed management research must include the development of seed bank management techniques.

What has been done
Research to: add to the body of knowledge on the influence of perennial crops, cover crops, and soil amendments on weed seed survival in cropping systems; to explore multiple strategies that manipulate and manage weeds in agronomic systems.

Results
Our researchers continue to investigate seed fate in soil aggregates in marginal and field crop ecosystems and plan to present a paper at a research conference this year. We will be publishing our research on the influence of crop rotation on Palmer amaranth seed persistence and management in Michigan, as well as the influence of cereal rye and soybean row width on suppression of Palmer amaranth in soybean. We
are beginning research to study how cover crop planting in the fall influences marestail emergence and management the following spring.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
216	Integrated Pest Management Systems

Outcome #10

1. Outcome Measures

Number of research programs to develop controls for pathogens and nematodes affecting plants.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Nematodes are among the parasites that attack numerous economically important plants, substantially reducing their yield potential by destroying their root system. Pathogen epidemics

are a constant problem for agriculture and are known to influence natural ecosystems, especially when alien pathogens successfully invade new areas.

What has been done

Research to facilitate the development of integrated tools that will lead to transformative approaches of soil ecosystem management and improve land use, food security, and loss of habitat and biodiversity; to increase the capacity of risk assessment to evaluate specific risk management strategies related to (I) Agriculture - Food, Feed and Fiber; (II) Environment; and (III) Food and Health; provide better manage strategies for both the beneficial and harmful effects these fungi in areas of food safety, sustainable agriculture, and the health of the planet and ourselves.

Results

Compounds derived from plants and microbes provide a rich source of biological activity that can improve human, animal and plant health. These natural products include pharmaceuticals, botanicals, functional foods, agrochemicals and animal health products. Research interest continues on phytochemicals in the diet that can combat chronic diseases such as cancer, inflammation, diabetes and cardiovascular diseases. Nutraceuticals or dietary supplements enriched in beneficial
phytochemicals or in purer forms are being developed by industry as functional foods and botanical drugs. The study of bioactive natural products, therefore, leads to a fuller understanding of biological systems related to human health, and to the discovery of compounds with beneficial properties that can be exploited commercially. The proposed project will discover biologically active natural products from generally regarded as safe (GRAS) plants, fruits, vegetables and other horticultural and agricultural crops. We will also determine the mode of action(s) of these bioactive constituents in order to process the respective plant material as products for agricultural, pharmaceutical and nutraceutical applications. This research should
yield value-added products and provide additional income to the growers in Michigan and USA. Also, based on the potential of nutraceuticals or botanical drug applications, new crops can be introduced to fill the need for nutraceuticals and botanical
drug industries. The results from this research should give a leading edge to agrochemical, food and pharmaceutical industries in Michigan and USA. This project also fits to the overall mission of Michigan State University AgBioResearch to be a leader in food and health, bio-economy and sustainable ecosystems initiatives and programs.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
206	Basic Plant Biology
212	Pathogens and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems

Outcome #11

1. Outcome Measures

Number of research programs to develop production protocols and environmental and cultural strategies for the floriculture/nursery industry.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The U.S. green industry experienced unprecedented growth, innovation, and change from 1980 to 2010. Recently, however, slower sales growth and reduced profit margins indicate the market is maturing. Prices usually decline and competition intensifies in mature markets, challenging all firms to become more effective with their resources to best connect with customers, generating revenue and profits. Michigan ranks among the top three states for floriculture crops and among the top 10 states in nursery plant production. Like the national trend, Michigan plant producers are experiencing a similar pattern of
slowing demand. While the horticulture industry's outlook may be somewhat uncertain, it is clear that innovativeness will continue to be a requisite skill in ensuring the survivability and profitability of green industry firms in the future. Whether producer or retailer, some business effort must be focused on enhancing the value proposition offered by firms. Businesses can improve their value proposition by emphasizing the economic, social (e.g., health and well-being), and environmental benefits (e.g., energy/water saving production methods, or use of recyclable/compostable containers) that green industry products and services offer end consumers (Hall and Dickson, 2011) over price, which is emphasized in undifferentiated
commodity sales. Still, reaching customers with value-added propositions will only be successful if the messages are conveyed
in a meaningful way.

What has been done
Research to: provide nursery managers, landscape contractors, and urban foresters with additional tools to improve the long-term success of landscape and street tree plantings; improve signage at the point of purchase (short term) and help firms enhance their value proposition by more effectively providing timely, useful, and pertinent information to customers; create a new model for science education; enable greenhouse growers to reduce energy costs for heating and light

Results
We have found that individuals who score high on the plant expertise scale do use more intrinsic cues compared to individuals who score lower on the same scale. We developed an objective expertise scale, but the subjective metric has a stronger relationship with plant choice. We plan to revisit the objective measure to make it more specific and a stronger metric. Novice consumers use brand more than "expert" consumers. Plant brands do influence the purchase decision of approximately 30% of the subjects in one of our published studies. When we showed them digitially identical plants, approximately 30% said that branded plants that appeared in the image (3 shown,
2 were branded) were of higher quality compared to the unbranded plant (despite the fact that the plants were digitally identical).
With funding from USDA-SCRI, we have identified four factors with regard to water conservation expertise and involvement that affect consumer perceptions of landscape plant water use.

4. Associated Knowledge Areas

KA Code	Knowledge Area
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

Outcome #12

1. Outcome Measures

Number of research programs to develop more effective post-harvest protocols and practices to minimize loss and enhance quality.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Farmers and food sellers have been concerned about losses since agriculture began. Yet the problem of how much food is lost after harvest to processing, spoilage, insects and rodents or to other factors takes on greater importance as world food demand grows. Cutting postharvest losses could add a sizable quantity to the global food supply and reduce the need to intensify production in the future. Estimates of total postharvest food loss are controversial and range widely, generally from about 10 percent to as high as 40 percent

What has been done

Research to: Improve orchard and vineyard postharvest technologies and postharvest recovery of sugars and pectic polysaccharides from plants; to test and recommend a series of vineyard management strategies that can hasten fruit development and maturation for improved and more consistent high quality grape production in a highly variable climate year to year; determine storage regimens for Honeycrisp and other apples prone to CA injury.

Results

In 2016 research experimental efforts were focused on determine yield ranges that could be matured over a variety of growing season types and vineyard canopy management practices, while maintaining the vine's capability to return with a full crop potential the next season. In wine grapes, the main technologically important quality compounds in berries are not only genotype dependent but are affected by vineyard manipulation techniques. Although winegrowers obviously cannot influence the vintage or change the region macroclimate or the vineyard mesoclimate conditions, they can adopt techniques to
significantly improve microclimate conditions within the cluster area. There are several techniques, and by carefully selecting the most relevant ones and by choosing the timing for their implementation at different grape developmental stages, they can impact positively the grape quality at harvest. Two in particular, the objectives of our studies in 2016 growing seasons. Leaf removal and yield adjustments are known to be viticultural practices improving canopy microclimate, pivotal in cool climates, leading to important grape quality improvements. Any significant vineyard management-related improvements in grape composition would normally be aimed to reflect also in the wines.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

During the 2016-17 fiscal year, ABR and MSUE support many areas such as our Enviro-weather stations. To assist Michigan producers with pest, plant production and natural resource management decisions, Enviro-weather provides weather data from a network of stations located throughout the state. Enviro-weather data are shared with other weather groups across the region and are also used in college and university classrooms to teach students about topics such as weather, agriculture and pest management. Since the

creation of the Enviro-weather program, data requests have grown from 96 on average per day to more than 450 in 2015.

Project GREEEN funds supported:

- Two tower stations added to the Enviro-weather network to provide real-time, cross-sectional temperature and wind information to fruit growers for monitoring low-level inversions and making decisions related to wind machine-based frost protection.
- Along with the two tower sites, three additional standard stations were added within the past year: Benona/Shelby, Michigan; Kewaunee, Wisconsin; and Grant, Michigan.
- Operational upgrades including strategic network and system modernization, as well as routine weather network maintenance.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

As Hatch dollars are base funding for faculty salaries, there is a built-in evaluation mechanism through annual reviews of overall performance, research productivity and the leveraging of additional research dollars. In addition, many of the research projects have an evaluative element that is required by state and federal-level funding sources that provides documentation related to project assumptions, goals and outcomes. This information is used to determine the overall success of the research initiatives; their contribution to providing practical, real-world solutions and resources to address challenges and problems; and whether continuation funding and/or new dollars are appropriate and necessary as funds are available.

Additional examples of programs with evaluation results for MSU Extension are:

IPM training for small fruit growers to prevent pesticide resistance and non-target impact of pesticides in small fruit production

Issue (who cares and why)?

Every year small fruit growers are faced with challenges resulting from weather, pest and disease problems and also environmental regulations that complicate their farming operations. In addition, new invasive insect pests and the down turn of the US economy has reduced their farm income due to a combination of increased expenses and falling berry prices.

For the past 3 years after the arrival of the spotted wing Drosophila (SWD) and the outbreak of secondary pest problems (Blueberry Stem Gall Wasp, and Putnam Scale, etc.) economical losses resulting from fruit infestation and high pest control expenses are forcing out of business many small growers (especially Hispanics, African American and undeserved growers with small number of acres in their farms).

At difference of other fruit industries, the Michigan small fruit industry relies heavily on MSU Extension for technical assistance. And for underserved, minority and new and beginning farmers MSU Extension programing and technical assistance is their only technical support for their operations. Thus, our IPM program provide small fruit growers with education on how to combat the major pest complex of berry crops, and at the same time preventing pesticide resistance and non-target impact of pesticides in small fruit production.

What has been done?

We accomplished this purpose through Twilight Meetings with PowerPoint presentations; training workshops (SWD); pest management updates, Factsheets, and MSU News articles delivered at the MSUE News website. Also field demonstrations on IPM techniques and updates on pest management practices and environmental regulation. For workshops and

twilight meeting lectures prepared in PowerPoint include **training notes.** And when possible, PP presentations are reviewed for relevance in content, clarity of wording, language and format to comply with MSU's web accessibility and English Language Proficiency (ELP) policy. Thus, for Spanish speakers, all PowerPoint presentations and training notes were translated into Spanish to facilitate learning by growers with limited understanding of English.

Results/Impact?

In 2017, the final evaluation via SurveyMonkey was mailed to 450 registered growers. We had 61 growers reporting back to use with their responses. Major results of our training were:

1. The major production problem in 2017 was weather; winter and spring frosts. A 39% of the growers indicated this as their major problem.

2. Insect pest management was the second biggest problem; 39% indicated insects as their major problem.

3. Major crop losses reported were result of weather conditions; a 45% reported spring frosts as their major cause of lost income.

4. Most important pest problem in 2017 was the spotted wing Drosophila with 88% of the growers signaling this pest as a major threat for their operation. It was followed by the Blueberry Stem Gall Wasp with 27% responses.

In regard to the importance of our IPM program; 86% of the growers responding our survey indicated they actively participated in our IPM program (SWD workshops, Twilight Meeting, etc.).

A 92% of those growers indicated they used what they learned at our meetings and workshop to manage the SWD and other pests.

The most important resource they used for pest management was; workshop training notes 87%; MSU SWD web site information 69%, and handouts at Twilight Meetings 68%.

In regard to the SWD, they reported on average 9 insecticide applications to control it; crop losses averaging 9.8% and pest control expenses of $191/acre.

Despite the difficult conditions in which small fruit production was conducted in 2017, due to early arrival of the SWD and hot summer conditions that allowed the SWD to get out of control in many places, growers attending our programs were successful at managing the SWD risk.

Although growers had to control the SWD much longer than in previous years, in 2017 their expenses for pest control were lesser than in 2014; $196 versus $375 /acre in 2014. Also, crop losses reported were much less than in 2014; 9.8% in 2017 versus 18.5% in 2014. In addition, 54% reported no crop losses at all versus 33% in 2014.

What difference did it make - public value?

IPM training of growers is making the difference. Growers with access to MSUE IPM training are successfully reducing crop losses due to insect pest problems such as SWD. That is critical to maintain Michigan's small fruit competitive. Also, for the sustainability of small farms and preservation of income and employment, especially for underserved, minority and new and beginning farmers. This is critical at the time when some growers that in 2016 & 2017 suffered extensive losses due to SWD are abandoning the industry.

Another example is:

Smart Gardening

Issue (who cares and why)?

According to the National Gardening Association, 70% of households engage in some type of gardening. Taking into consideration 2010 census data from MI households and average number of people per household, this equates to a potential consumer horticulture audience of over 6.7M Michigan citizens.

The actions of home gardeners positively or negatively impact many important aspects of a

sustainable future such as water quality, food security, healthy soils, and pollinator protection. These actions can be influenced by science-based gardening information.

What has been done?

Michigan State University Extension's Smart Gardening Initiative capitalizes on delivery of a wide variety of earth-friendly messages to home gardeners that have unique learning styles. Many methods of communication are used including print, web-based, video and media and face-to-face at public venues such as a home and garden show. While shows outreach events help home gardeners learn basic concepts of smart gardening, a venue such as the daylong Smart Gardening Conferences allow participants to dig deeper for greater understanding of these research-based subjects.

Results

One evaluation of a Smart Gardening training found:

- 91% of them responded as having a better understanding of a sustainable landscape and how to implement more sustainable gardening practices in their own home garden and yard
- 76% of them responded as having a better understanding of methods to use to increase their garden's productivity.
- 97% of them selected at least two or more of the sustainable landscape techniques listed and plan to apply them. Of those Smart Gardening practices (sustainable landscape techniques) listed, the following percentages plan to apply them:
- 74% will develop flower borders that attract beneficial insects.
- 68% will increase diversity of plants available.
- 62% will select plants that are better suited to their site.
- 59% will incorporate water efficiency with use of drip irrigation.
- 56% will incorporate compost and organic matter annually.
- 53% will leave lawn clippings on the lawn.
- 50% will make use of organic mulch.
- 50% will mulch leaves into their lawn.

Key Items of Evaluation

MSU AgBioResearch

Controlling Soybean Diseases with Lab, Field Tools (**https://tinyurl.com/y86pc6ak)**

According to the Michigan Soybean Promotion Committee, soybeans contribute $1.67 billion to the state's economy each year -- and more than 14,000 jobs.

The soybean, which is native to East Asia, is a versatile plant that serves a multitude of purposes. Raw soybeans are toxic to people, so most are processed for the oil, which is refined for human consumption. And soybased foods such as soy milk and tofu are popular substitutes for dairy and meat products.

The extracted oil can also be used to create fuels, lubricants, cleaning solutions and other bioproducts. Animal feed is often made from the fiber left over after removing the oil.

"Soybeans are a crucial component of Michigan agriculture," Chilvers said. "Ever since I arrived at MSU, my team and I have been active in meeting with soybean growers to learn about how we can best serve their needs. Several diseases affect soybeans, and we've done a lot of work with them."

With funding from MSU Project GREEEN (Generating Research and Extension to meet Economic and Environmental Needs) and the U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture, Chilvers has led a team of scientists from across the country to identify the diversity and prevalence of fungus-like soybean diseases in 11 states.

- Numerous species of fungus-like organisms called oomycetes cause soybean seedling blight.

• In addition to his work with oomycetes, Chilvers has tackled other soybean challenges such as sudden death syndrome and white mold, and diseases of corn, dry bean and wheat.

• **According to the Michigan Soybean Promotion Committee, soybeans contribute $1.67 billion to the state's economy each year -- and more than 14,000 jobs.**

Breeding Better Wheat

Ensuring that Michigan farmers have the best tools to meet emerging challenges and continue to produce wheat at record-setting levels lies at the heart of the Michigan State University wheat breeding and genetics program.

To develop the best new varieties of wheat and get them in the hands of farmers as quickly as possible, the team blends traditional plant breeding with cutting-edge genomic technology.

Through genomic selection, breeders can read and analyze the genotype - the collection of genetic information - of the new varieties they develop as early as the first cross. This helps predict in the lab how they will perform long before they make it to the field.

In addition to breeding new varieties, the team conducts research on wheat genetics, adding new genetic information to the pool of breeding resources. They are working to clone new genes for disease resistance from goatgrass. They are also making progress toward discovering genes that could increase grain yield by maximizing the energy generated through photosynthesis.

• **Michigan ranks 12th nationally in wheat production, with over 600,000 acres and 8,000 farmers adding $388 million to the state's economy.**

MSU Extension

Youth

- 22,808 youth trained in Plant Sciences.
- 8,690 youth trained in Biological Sciences

Adults

- 9,219 adults were trained in Consumer Horticulture
- 6,957 adults were trained through the Smart Gardening Initiative
- 6,312 adults were trained in Field Crops
- 3,543 adults were trained in Vegetable
- 3,396 adults were trained in Fruit
- 2,010 adults were trained in Ornamental Horticulture

V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Economics, Marketing and Policy

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
601	Economics of Agricultural Production and Farm Management	35%		10%	
602	Business Management, Finance, and Taxation	40%		7%	
603	Market Economics	0%		10%	
604	Marketing and Distribution Practices	5%		9%	
605	Natural Resource and Environmental Economics	0%		12%	
606	International Trade and Development	0%		11%	
608	Community Resource Planning and Development	20%		10%	
609	Economic Theory and Methods	0%		12%	
610	Domestic Policy Analysis	0%		11%	
611	Foreign Policy and Programs	0%		8%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	27.9	0.0	6.5	0.0
Actual Paid	24.6	0.0	13.0	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
1155043	0	898338	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1155043	0	938571	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	5788599	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Research programs to:

• Identify current and emerging key public policy issues on trade, environmental, agricultural and food issues important to Michigan and analyze responses.
• Conduct research and education to improve the operations, business and financial management skills of Michigan producers so they can make decisions that are more sound financially and environmentally.
• Evaluate the competitiveness and marketing strategies of Michigan farm markets, greenhouses and other green industry retailers.
• Develop a framework to understand and analyze domestic and international trade policies and assess their impact on Michigan.
• Evaluate how Michigan citizens use the Internet when searching for information about a vacation destination or planning a vacation.
• Determine rationale for farmland preservation choices and how changes will affect the Michigan tax base.
• Develop models to estimate the demand for and value of recreational fisheries and wildlife resources.
• Identify and evaluate the policy, technology and marketing issues faced by Michigan organic growers and develop responses.

Extension program activities to:

• Teach financial management skills, business organization, estate planning, management information systems, strategic management, alternative sustainable production and marketing systems to agriculture and natural resources producers and businesses.
• Assist agencies, organizations, local governmental units and individuals in pursuing a cultural economic development strategy.
• Offer business retention and expansion support.
• Help people recognize, understand and appreciate multicultural differences.
• Provide entrepreneurship education to a broad audience, including individuals, business owners, youth and communities.
• Offer communities consultative, diagnostic and educational assistance in planning and zoning to meet community land use goals.

2. Brief description of the target audience

Agriculture and natural resources producers and industry representatives; tourism industry

representatives; state agency representatives; private citizens; school administrators; local, state and federal elected officials and policymakers.

3. How was eXtension used?

MSU Extension continues to utilize eXtension as one of the primary multi-state activities that involve contributing to Communities of Practice, responding to Ask an Expert questions, and contributing to innovation projects. One example in this area was: developed a series of webinars related to promoting equity in the food system.

V(E). Planned Program (Outputs)

1. Standard output measures

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	9649	28947	998	998

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2017
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	0	38	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research programs on economics, marketing and policy.

Year	Actual
2017	42

Output #2

Output Measure

- Number of adult participants trained in economics of agricultural production and farm management.

Year	Actual
2017	2901

Output #3

Output Measure

- Number of adult participants trained in business management and finance.

Year	Actual
2017	1385

Output #4

Output Measure

- Number of adult participants trained in community resource planning and development.

Year	Actual
2017	5363

Output #5

Output Measure

- Number of youth participants trained in entrepreneurship.

Year	Actual
2017	998

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of adult participants with increased knowledge in economics of agricultural production and farm management.
2	Number of adult participants with increased knowledge in business management, finance and taxation.
3	Number of adult participants with increased knowledge in community resource planning and development.
4	Number of research programs to identify current and emerging key public policy issues on trade, environmental, agricultural and food issues important to Michigan and analyze responses.
5	Number of research programs to improve the operations, business and financial management skills for Michigan producers so they can make decisions that are more sound financially and environmentally.
6	Number of research programs to evaluate the competitiveness and marketing strategies and human resources management practices of Michigan farm markets, greenhouses and other green industry retailers.
7	Number of research programs to develop a framework to understand and analyze domestic and international trade policies and assess their impact on Michigan.
8	Number of research programs to develop models to estimate the demand for and value of recreational fisheries and wildlife resources.
9	Number of youth with increased knowledge in entrepreneurship.

Outcome #1

1. Outcome Measures

Number of adult participants with increased knowledge in economics of agricultural production and farm management.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	2552

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Farm business owners struggle with understanding exactly where the business financially stands. Huge production swings, volatile prices, timing of sales and inputs, and changes in inventories, prepaid expenses and unpaid bills make it difficult to get a good measure of actual profitability in an effective structure that not only communicates efficiently to business owners but also to outside appropriate people including consultants, lenders and others. In addition, tight or negative profit margins, changing markets, the ag industry changing structures, new technological advances, have contributed to enhanced need for financial analysis, projections and comparative financial studies to enable producers to make informed logical decisions.

What has been done
MSUE provides technical assistance and consultation to farmers and producers to respond specifically to their needs. Services have included financial analyses & projections.

Results
In one example that was evaluated, sixty-three FINANs, 17 FINLRB and 15 FINFLO analysis and/or financial projections were completed with individual personal educational consultations (PEC). Evaluation results found: 24 business expansions were made resulting in $5,091,523 capital investment stimulating additional ripple effect long-term economic growth. Other farms secured operating capital by securing loans and restructuring debt.
Supporting Agriculture families to maintain competitiveness, viability and growth is important for local communities and the state of Michigan. Agriculture is the state?s second largest primary industry. Without primary industries, there is no need for secondary attendant industries such as government, schools, infrastructure, banking and other services.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
602	Business Management, Finance, and Taxation

Outcome #2

1. Outcome Measures

Number of adult participants with increased knowledge in business management, finance and taxation.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example in this area is farmers need information and skills to manage their farm business and taxes. This not only plays into profitability but often times can make the difference between success and failure and possibly losing the farm.

What has been done
One of the programs in this area is the MSUE TELFARM Tax Management program. Farm producers enrolled in the program during December, before the end of the tax year, to manage their taxable income. Small business operations and especially farmers on cash accounting systems for income tax have the ability to strategies when to sell products, buy products and buy capital items to take advantage of financial and production benefits. This has major tax implications from the exposed taxable income. Income tax management goal is to get the maximum income through the tax system as possible, at the lowest cost possible, over time. The overtime part is especially difficult with agricultural operations because of the extremely variable yields, prices and input cost. A farmer has more variability in net income from year to year than nearly any other businesses. Tax professionals often do not have a good sense of probable future earnings.

Results
For this example, forty-seven (47) mid-Michigan farm families (nearly 100 people) met individually with Extension professionals to develop their business?s tax management strategy for the current year. An excel spreadsheet was utilized to help people develop their plan. Another Excel Spreadsheet was used to help people target their optimal income.

Evaluation results found on average, the tax savings was $17,649 per family totaling $830,000 total benefit for the effort.
What difference did it make - public value? Supporting agriculture to be financially strong, competitive, and keeping these dollars at home has significant economic impact to Michigan and local economies. Agriculture is the second largest primary industry in Michigan. Without primary industries, there is no need for secondary attendant industries such as government, schools, infrastructure, banking and other services.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
602	Business Management, Finance, and Taxation

Outcome #3

1. Outcome Measures

Number of adult participants with increased knowledge in community resource planning and development.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	4290

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The need for programs in this area are based on:
- Many Michigan communities still face old economy legacies and are grappling with serious fiscal stress. Community leaders need knowledge and skills in how to plan for and embrace the new economy and manage financial and capital assets to be more competitive in the future. MSU Extension should ?take a greater role in educating local government on emerging issues? (Issue Identification survey).
- Many Michigan communities face high turnover rates among elected and appointed officials and routinely have individuals serving without adequate training in local governance and finance, planning, zoning and placemaking. Without these fundamental skills, communities cannot fully benefit from training on more advanced concepts that inform key policy issues in Michigan. MSU Extension should ?Provide leadership development and civic engagement for youth and adult audiences within the community? (Issue Identification survey).

What has been done
MSU Extension developed several program under the Government and Public Policy workteam. The programs engage participants in learning skills of good governance, how to communicate with purpose, and how to collaborate on solving complex issues in order to improve their communities. Programs included:
- Placemaking, regionalism, and strategic growth education, facilitation, technical assistance, citizenship, and civic engagement.
- Community resiliency education and technical assistance.
- Workshops based on topics of interest and urgency related to public policy, effective management, municipal finance, land use, public participation/civic engagement and leadership of local and tribal government.
- Local and tribal government strategic planning, facilitation, and technical assistance.
- Programs on how to effectively manage conflict, communicate with purpose, and collaborate on solving complex issues.

Results
Evaluation results from 2017 found:

- 94% of the participants gained knowledge and skills in managing conflict, civic participation, communication, leadership, and/or facilitation.
-93% of the participants could identify and locate resources for quality information and/or apply that information to the solution of problems.
-89% of the participants increased understanding of relevant laws and the practical impacts of those laws on their group.
- 86% of the participants increased their knowledge of their group?s structure, functions, duties, and short-term/long-term fiscal situation.
- 81% of the participants increased their knowledge of citizen input processes and /or methods to implement those practices.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development

Outcome #4

1. Outcome Measures

Number of research programs to identify current and emerging key public policy issues on trade, environmental, agricultural and food issues important to Michigan and analyze responses.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	20

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Public policy has taken on considerable importance to the future of agriculture. The farmer's historic struggle was with the forces of nature and the marketplace, and government policy played a minor role. Government policy at all levels now is a major player in agriculture, especially related to agriculture as an important economic asset - the sustainability of a productive agricultural sector balanced with the preservation of environmental quality and the importance of prime farmland with respect to the continued viability of the rural economy and of rural lifestyles.

In general, Michigan is becoming warmer (1 degree warmer on average in the past 120 years) and wetter (a 10 to 15 percent increase in precipitation over the same period). And the growing season has lengthened by about 1.5 weeks in the past 30 years, resulting overall in new challenges and opportunities for the state's agriculture industry.

What has been done
Research to: develop a dynamic model to analyze the long-run impacts of renewable energy development on fossil fuel supply; provide a more comprehensive understanding of tourist preferences for tourism management and development; provide information that can contribute to better design and better use incentive-based conservation; develop rural Latino communities in Michigan; develop environmentally benign bioprocesses to effectively utilize various renewable resources; visually characterize changes in food and agricultural systems examine the implications of sustainability principles for U.S. agriculture; elucidate the role of economics and law on environmental management; develop, extend and apply economic and ecological theory to analyze economic and ecological trade-offs associated with ecological problems; and to better understand impacts of climate change on crops; sustainable bioenergy systems; telecoupling food security and land use; and integrated farm-based refining for chemical and bio-fuel production.

Results
Annual soil moisture drawdown and recharge cycles under a continuous corn production system were examined and found to correspond to annual and seasonal precipitation totals, with greatest annual amplitudes in eastern and southern sections of the domain and the least in the west. Complete seasonal recharge as defined by 100 percent of plant-available moisture in the rooting zone was reached on a consistent (more than 50% of the years) basis across approximately the eastern half of the region. In far eastern sections of the domain from Michigan southward through eastern Ohio to southern sections of Indiana, Illinois, and Missouri, recharge was reached more than 90% of the years. The average date of recharge generally ranged from DOY 60-90. This pattern appeared to be associated with relatively greater cold season precipitation totals. In western portions of the region where recharge did not regularly occur, greatest mean seasonal plant available soil moisture levels were reached from DOY 140-170, which corresponded with seasonal increases in precipitation rates. Earlier mean seasonal maxima tended to be located across southern sections of the domain and later in the north, which reflects south to north differences in timing of the cropping cycles. Seasonal drawdowns were greatest from approximately DOY 170-220, which closely corresponds with crop growth stages just prior to

anthesis through early grainfill when crop water needs are relatively greatest. The average timing of lowest seasonal plant available water generally ranged from DOY 240 in western sections to DOY 260 in eastern sections. Soil type had some influence on the magnitude and timing of the seasonal maxima and minima (e.g. lower frequency of recharge for coarse-textured soils), but the impact was overall less than that associated with annual
and seasonal precipitation totals.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
605	Natural Resource and Environmental Economics
608	Community Resource Planning and Development
610	Domestic Policy Analysis

Outcome #5

1. Outcome Measures

Number of research programs to improve the operations, business and financial management skills for Michigan producers so they can make decisions that are more sound financially and environmentally.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	12

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Natural resource management involves making decisions in the face of both conflicting objectives and great uncertainty about the outcome of those decisions. Two critical shortcomings of historical decision making involving natural resources have been (1) inadequate or inappropriate consideration of uncertainty; and (2) a failure to effectively engage stakeholders in the decision-making process. Decisions made without appropriate recognition of uncertainty have often been based on optimistic judgments of the effects of management decisions because the risks of undesirable consequences are not

properly considered. Many natural resource management "failures", such as commercial fishery collapses, have resulted from this failure to recognize the risks associated with management decisions. There are many examples worldwide of failures to protect stocks from collapse due to overfishing and of unsuccessful, and sometimes costly, attempts to rehabilitate degraded fish populations. Conversely, arbitrary yet conservative adjustments to management strategies to qualitatively account for risk can limit opportunities for socially and economically beneficial uses of natural resources.

Natural resource management agencies have traditionally involved stakeholders in the decision-making process primarily after the decision problem has been analyzed and a possible solution or decision has been identified. More recently stakeholder groups have been invited to provide input at the start of a decision-making process, but then left out of the analytical steps that lead to the recommendation decision. This approach to engagement lacks transparency, and combined with the, at best, mixed track record of natural resource decision-making, has led to a serious erosion of trust among many stakeholders. Consequently, stakeholders have begun to demand a greater degree of involvement in the management process.

What has been done
Research to: explore, analyze and evaluate the dynamics and economic impact of entrepreneurial activity within the context of MI and global agrifood systems; further the understanding of coupled human and natural systems and sustainability; more broadly develop conceptual and analytically frameworks for understanding, assessing and empirically studying effective innovation in the agriculture, food and natural resource sectors; examine the causes and consequences of Michigan state and local government fiscal challenges; to discern the relationship between entrepreneurship and the Michigan agrifood sector; to develop sustainable energy and business systems; understand agricultural production economics in an environmentally conscious manner; to improve the quality of natural resource management.

Results
During the past year we completed research to examine trade-offs between lampricide control of larval sea lampreys and the use of traps to remove adult lampreys. As part of the same project we modeled the consequences of dam removals from streams utilized by sea lampreys for Great Lakes sea lamprey populations and showed that removals result in a disproportionately large increase in pest production if control budgets are not increased to offset the creation of additional rearing habitat caused by the dam removal.

For another project, entrepreneurship is generally regarded as a catalyst for regional economic growth and has been increasing viewed as a
strategy to improve the decision-making and performance of food and agribusiness firms. This project seeks to enhance and support entrepreneurial activity in the agri-food sector for these purposes. The project has, and continues to, deliver new knowledge and resources to key stakeholders and has contributed to Michigan's thriving food economy. In particular, it has supported the rise and rapid growth of Michigan food entrepreneurs (via the MSU Product Center), food hub businesses, food retailers, wineries and related businesses (vineyards), and agribusinesses. Each of these business enterprises has the potential to be a significant driver of rural economic development in their respective communities.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management

602 Business Management, Finance, and Taxation
604 Marketing and Distribution Practices

Outcome #6

1. Outcome Measures

Number of research programs to evaluate the competitiveness and marketing strategies and human resources management practices of Michigan farm markets, greenhouses and other green industry retailers.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Tourism is one of the largest industries in Michigan and offers a viable and growing alternative to manufacturing throughout the
state. Much of Michigan's tourism industry is directly or indirectly dependent upon outdoor recreation and associated outdoor
settings. Full realization of tourism's potential as a form of economic and community development will require both the
strengthening of Michigan's existing tourism product as well as the provision of appropriate new product that appeals to today's
traveler. Michigan is blessed with a diversity of natural and cultural landscapes and attractions; the project proposed will
investigate ways in which to capitalize upon these resources while minimizing negative impacts on their availability and quality,
thereby maintaining the image on which the multiple-award winning "Pure Michigan" tourism marketing campaign continues to
be built.

What has been done
Research to:investigate ways in which to capitalize upon resources while minimizing negative impacts on their availability and quality,thereby maintaining the image on which the multiple-award winning "Pure Michigan" tourism marketing campaign continues to be built.

Results

Numerous activities contributed to improved understanding of the importance of tourism - as well as the importance of specific natural resource-based tourism assets such as water and trails - among community members (including the tourism industry, elected officials, economic development and planning staff, and residents). Such efforts encourage both increased/improved (i.e., more effective) marketing of these assets, as well as increased awareness of the need to protect their integrity and quality. Other activities contributed to the development and application of new methods to natural resource/environment-related issues, in particular their more effective planning and management.

4. Associated Knowledge Areas

KA Code	Knowledge Area
602	Business Management, Finance, and Taxation
603	Market Economics
604	Marketing and Distribution Practices
608	Community Resource Planning and Development
609	Economic Theory and Methods

Outcome #7

1. Outcome Measures

Number of research programs to develop a framework to understand and analyze domestic and international trade policies and assess their impact on Michigan.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	6

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The ability to understand the economic, cultural and political factors of domestic and international trade policies in order to determine the likely changes in these policies and their consequent market is essential to a competitive, sustainable Michigan economy. Research in this arena will provide information and resources that are critical to Michigan businesses, either directly or

indirectly, as the balance of power within the marketplace shifts. As globalization of food industries continues, an assessment of such power requires analysis of world trends and the institutional structures that govern national and international actions.

What has been done
Research to: provide economic analysis of agricultural production technologies and management practices related to the many agricultural enterprises important to Michigan farmers; better understand the supply chains of various horticultural products; and identify ethical issues in agriculture; and increase innovation, entrepreneurship and sustainability in MI and globally in agri-food and value chains; and global partnership for food security and economic growth.

Results
On one of the project, we derived information from rural-urban value chain studies in Indonesia on mangoes and Bangladesh and India on potatoes,and herbicides to horticulture crops, to inform the patterns, determinants, and effects of development of these chains on the local economies and supply to urban consumers, as well as farm household welfare.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
605	Natural Resource and Environmental Economics
606	International Trade and Development
610	Domestic Policy Analysis
611	Foreign Policy and Programs

Outcome #8

1. Outcome Measures

Number of research programs to develop models to estimate the demand for and value of recreational fisheries and wildlife resources.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The implications of embracing alternative governance models, particularly collaborative governance, in resource management and larger sustainability initiatives will be a central focus. The contributions of Michigan's natural resources to the State's economic health are widely cited. Land, water, forest resources, fish and wildlife and associated habitat, and ecosystem functions and services are but a few of the critical resources that play a significant role in numerous sectors of Michigan's economy. While discussions of sustaining a sufficient quantity of these critical resources are common, debate has tended to focus on how much of the resource can or should be used in total, with less direct attention to questions raised by competition for the resource. While resource users express concerns about the quality and quantity of the state's natural resources, state policy has not kept pace with the resource competition and resource degradation concerns, nor the restoration and regeneration needs, evidenced by the state's natural resource issues.

What has been done
Research to: identify and evaluate natural resource governance models for effective policy and management of local, regional and state-level natural resource problems in Michigan.

Results
Data analysis is being conducted to estimate irrigation water demand for Great Lakes States and impact of changing climate on irrigation water demand.

4. Associated Knowledge Areas

KA Code	Knowledge Area
603	Market Economics
605	Natural Resource and Environmental Economics

Outcome #9

1. Outcome Measures

Number of youth with increased knowledge in entrepreneurship.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	965

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Youth need information and opportunities to explore their future careers and interests, and, possibly, consider being an entrepreneur.

What has been done
MSU Extension 4-H programs are youth focused and designed to:

- increase life skills and leadership skills,
- increase (critical thinking skills) (science literacy), leadership and employability skills,
- build cultural competencies and engage in the world around them as active citizens and learn that their voice and actions can make a positive difference.

One example is the Michigan 4-H Veterinary Science Teen and Adult Leaders Workshop where funding and sponsorship was made possible by GreenStone Farm Credit Services and the Michigan 4-H Foundation.

Objectives of this conference was:
- Present new ideas, activities and approaches to the 4-H Veterinary Science Program.
- Teach skills in areas of veterinary medicine and management.
- Give workshop participants opportunities to explore new ideas in-depth and get a hands-on experience.

Participants had 10 contact hours with 9 MSU faculty along with 5 MSU College of Veterinary Medicine students and 2 industry representatives and other volunteer resource people.

Results
Evaluation results from 77 youth (61% of the tot?al youth participants) found:

- 97% of the participants agreed or strongly agreed that they were more knowledgeable about veterinary science as a result of the workshop.
- 95% said after the event, they felt more knowledgeable about entrepreneurship and career opportunities they can pursue in science-related fields.
- 97% plan on applying the science knowledge and skills from this workshop.
- 97% indicated they are aware of the science skills learned through the workshop.
- 91% indicated they can identify the science learned through the workshop.
- 95% indicated that after this training they have a plan for reaching their goals.

Some examples of the comments from the youth were:
"I found this extremely helpful because it opened my eyes to the endless career choices that are available through 4-H and animal science."
"This program was beneficial because it helped me learn more about being a vet and what to experience when working with animals."
"It was very informational and taught me a lot more about animals. It also encouraged me to pursue my Vet dream."

4. Associated Knowledge Areas

KA Code	Knowledge Area
602	Business Management, Finance, and Taxation

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

During the 2016-17 fiscal year, ABR and MSUE support many areas such as our Enviro-weather stations. To assist Michigan producers with pest, plant production and natural resource management decisions, Enviro-weather provides weather data from a network of stations located throughout the state. Enviro-weather data are shared with other weather groups across the region and are also used in college and university classrooms to teach students about topics such as weather, agriculture and pest management. Since the creation of the Enviro-weather program, data requests have grown from 96 on average per day to more than 450 in 2015.

Project GREEEN funds supported:

- Two tower stations added to the Enviro-weather network to provide real-time, cross-sectional temperature and wind information to fruit growers for monitoring low-level inversions and making decisions related to wind machine-based frost protection.
- Along with the two tower sites, three additional standard stations were added within the past year: Benona/Shelby, Michigan; Kewaunee, Wisconsin; and Grant, Michigan.
- Operational upgrades including strategic network and system modernization, as well as routine weather network maintenance.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

As Hatch dollars are base funding for faculty salaries, there is a built-in evaluation mechanism through annual reviews of overall performance, research productivity and the leveraging of additional research dollars. In addition, many of the research projects have an evaluative element that is required by state and federal-level funding sources that provides documentation related to project assumptions, goals and outcomes. This information is used to determine the overall success of the research initiatives; their contribution to providing practical, real-world solutions and resources to address challenges and problems; and whether continuation funding and/or new dollars are appropriate and necessary as funds are available.

Other MSU Extension program evaluation examples:

Product Center

Issue (who cares and why)?

One example in this area is a Philadelphia based cold cappuccino coffee maker purchased

an existing facility in Muskegon county. Needed assistance with Michigan Department of Agriculture and Rural Development (MDARD) required programs or they would not be able to open. Important for facility to obtain licensing because of significant financial investment and job creation for the county.

What has been done?

MSUE worked with client on MDARD requirements and other aspects of facility for obtaining their licensing. Wrote several programs to assist with the timeliness of the project and plan.

Results/Impact?

Client was given their license by MDARD. They invested $11,000,000 into the facility and equipment and created 40 jobs.

What difference did it make - public value?

New company in Michigan employing 40 local residents. Increased tax dollars and economic growth to the county of Muskegon.

The Michigan State University Product Center is a collaboration between AgBioResearch, College of Agriculture and Natural Resources, Department of Agricultural, Food and Resource Economics, Center for Regional Food Systems, MSU Extension, MSU Undergraduate Entrepreneurship Program, Project GREEEN, and the university itself. Itworks with entrepreneurs to grow businesses, create jobs, andstrengthen the economic vitality of Michigan communities. The center connects food entrepreneurs with innovation counselors who offer the latest research, help identify markets, innovate new products and help guide the process from concept to launch. In 2017, the Product Center served 689 clients with 91 ventures launched, adding 461 jobs, and created a Total Capital Formation of $53,435,370.

Another example is:

First Impressions: Assessing your community for tourism (FIT)

Issue

Many Michigan communities rely on tourism as their primary industry, or they are seeking to reap the benefits of Michigan's growing tourism industry by establishing their communities as tourism destinations. In the many Michigan communities that depend on tourism, sustainable growth is going to come from regional collaboration and the fostering of small businesses that provide products and services to visitors and residents. Natural resources and agriculture are the basis for tourism in many regions, and they provide opportunity to develop small businesses related to nature-based tourism, cultural and/or historical tourism, and farm-based activities resulting in agritourism and/or culinary destinations. In addition to the resource-rich areas providing grass roots attractions, the downtown areas of rural/urban communities serve as attractions and destinations for visitors and potential residents, too.

The following data from the Tourism team's workshop, Understanding Tourism for MI Communities, says much about the importance of Michigan's tourism and continued development of research-based programming from MSU Extension:

- Over 113 million people visited Michigan in 2014
- 214,000 people are employed in Michigan's tourism industry - equivalent to every resident of Illinois, Indiana, Ohio and Wisconsin visiting MI 3X/year
- Without Michigan's tourism industry the unemployment rate in 2014 would have been 13.3% instead of 7.3%
- In 2014 tourism generated 2.4 billion in state and local taxes

- If MI tourism were a single business it would rank 132 on the Fortune 500 list - bigger than Time Warner
- Return on investment for every dollar spent on tourism in MI is estimated to be $6.87

Response

In 2017, Michigan State University Extension's tourism educators secured funding from Michigan's Prosperity Region 6- a seven county partnership comprised of Genesee, Huron, Lapeer, Sanilac, Shiawassee, St. Clair, and Tuscola Counties - to conduct four FIT programs in four communities. Via an application process, four communities were selected across the seven-county partnership to undergo a community assessment by a team of unannounced visitors during early Summer 2017. As part of the FIT program, each FIT community was responsible for constructing a community leadership team (CLT) comprised of members they felt best represented their community. The CLT was then responsible for organizing a community report forum (CRF) where assessment results were shared to the general community after having been completed. Upon completion of the CRF, each community was provided a summarized report of the results, the raw data collected from visitors, and a copy of the PowerPoint shared during the CRF. Each community was then allocated $2,000 from Prosperity Region 6 as seed money to launch various projects they identified as a need after receiving program results from their CRF.

Results

The FIT 2017 programs reached a total of 174 people. Of 174 people reached, 99 (or 57%) voluntarily took our program survey after attending their CRF. When asked if participants' feel the FIT program can help MI communities interested in developing tourism, 99% said "yes".

As a result of participating in FIT, participants were asked if:

1.) My awareness of community assets increased? 82% of participants agreed or strongly agreed

2.) My knowledge of how to maximize assets increased? 84% agreed or strongly agreed

3.) The program information shared will help strengthen collaboration within the community? 88% agreed or strongly agreed with this statement

4.) I envision myself or community using the information shared to advance tourism in my community? 90% of participants agreed or strongly agreed

Participants were also asked to comment how they felt the FIT program helped increase their awareness of community assets. Below is a summarized list of responses.

- The program provides info from an outside perspective and helped us see assets we didn't realize we have. It awakened us!
- It verified my hopes and goals for our community.
- Generated ideas for networking with other communities in the region.
- Things taken for granted suddenly seem to have tourist potential
- We have a tendency to pass the assets we have, it is great to be reminded
- I never thought about the small details that these visitors picked up on and how we looked online.
- The program identified several pathways to organize around.

Participants were asked to specify any short-term actions over a 1-6 months' period they intend to take as a result of participating in the FIT program. Below is a summarized list of responses.

- Develop and/or improve trail signage for bikers and kayakers, and kayak launches too.
- Become more involved with our community leadership team (CLT), community events, community development, and/or become an ambassador for the community.

- Improve our Chamber website and other business websites
- Open my business downtown and work on new storefront development.
- Encourage event coordination with Hispanic communities and businesses.
- Work with existing businesses to develop a sense of community.
- Promote historical features in our community and new murals too.
- Develop local tours for visitors and better communication tools for visitors/residents too.

Key Items of Evaluation

MSU AgBioResearch
Developing biobased production systems for commercial application (https://tinyurl.com/ycctjw87)
Food and energy are two of the most controversial topics around the world today, with policy debates dominating the political arena and captivating the public. Differences of opinion abound, but one thing is certain: As the world population balloons, more food and energy will be consumed. Therefore, sustainable methods of food and energy production need to be realized.
Much of the energy angst centers on the economics of fossil fuels. There are a host of concerns that cite issues such as job security for the industry or the upfront costs of moving to renewable energy systems. Abandoning fossil fuels altogether is unrealistic in the short term, but what if these production approaches could be supplemented by bioprocesses?
Most people have heard about biofuels. They constitute a burgeoning industry valued at more than $168 billion per year. Less is known about bioprocesses, the sustainable production techniques used to create products such as biopesticides, enzymes and organic chemicals. Yan "Susie" Liu, an associate professor in the Department of Biosystems and Agricultural Engineering at Michigan State University (MSU), has devoted her career to taking bioprocesses and technology from the lab to the marketplace.
Developing biodegradable plastics to reduce negative environmental impacts
Auras and collaborators developed a biodegradable mulch film along with a black film used for weed suppression.
Plastics are among the most widely used products in the world today, but there's a catch: Americans toss out more than 30 million tons of plastic each year, with less than 10 percent getting recycled. Because of its molecular structure, conventional plastic can take upwards of 1,000 years to degrade in a landfill. Rafael Auras, an associate professor in the School of Packaging at Michigan State University, believes this is a problem that can be solved through utilization of biodegradable and compostable materials.
Agricultural applications of plastic include mulch films, which suppress weeds, retain soil moisture and soil bed structure, and control soil temperature, among other benefits. Mulch films have traditionally been made of petroleum-based, nonbiodegradable plastics. When they are contaminated in the field, it is costly to remove and recycle them.

- Auras and collaborators performed a study placing three mulch films over the beds of tomato plants. He found that the white biodegradable film was compromised quickly, primarily through sunlight damage (photodegradation), resulting in poor performance. The black film, however, maintained its structure longer and was comparable in weed suppression to the conventional plastic.

MSU Extension
Youth

- 4,845 youth were trained in Career Exploration and Workforce Preparation
- 1,407 youth were trained in Financial Literacy
- 998 youth were trained in Business and Entrepeneurship

Adults

- 2,901 adults were trained in Agriculture Business Management
- 5,363 adults were trained in Government and Public Policy
- 1,049 adults were trained in Entrepeneurship and Business
- 893 adults were trained in teach youth principles of Career Exploration and Workforce Preparation
- 336 adults were trained in Tourism

V(A). Planned Program (Summary)

Program # 5

1. Name of the Planned Program

Animal Production and Protection

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
301	Reproductive Performance of Animals	0%		14%	
302	Nutrient Utilization in Animals	0%		10%	
303	Genetic Improvement of Animals	0%		10%	
304	Animal Genome	0%		10%	
305	Animal Physiological Processes	0%		9%	
307	Animal Management Systems	80%		12%	
308	Improved Animal Products (Before Harvest)	0%		1%	
311	Animal Diseases	10%		15%	
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals	0%		2%	
315	Animal Welfare/Well-Being and Protection	0%		9%	
605	Natural Resource and Environmental Economics	5%		8%	
806	Youth Development	5%		0%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	14.4	0.0	9.5	0.0
Actual Paid	17.7	0.0	12.0	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
820785	0	876428	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
820785	0	915679	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	5647414	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Research programs to:

- Understand the processes that control/influence reproduction at the molecular and genetic level.
- Develop and test new cropping, grazing and feeding strategies for food animals.
- Develop and evaluate management/training strategies for race horses to reduce injuries.
- Add to the understanding of various food animal genomes by improving and integrating genetic maps.
- Understanding of the genetic and molecular processes that control/influence the immune system in food animals to create new disease detection and tracking technologies.
- Develop and evaluate new tools and strategies to detect, prevent and control emerging and reemerging livestock and poultry diseases.
- Understanding of the environmental fate and biological effects of vaccines, steroids and other drugs fed to animals.

Extension activities to:

- Assist beef producers with implementing the mandatory electronic identification system and demonstrate methods to use the system to sharpen management skills.
- Provide livestock producers with knowledge and skills to develop and maintain herd-health systems.
- Provide animal industry with up-to-date animal health information.
- Improve farm-specific environmental stewardship related to manure management, including developing whole-farm nutrient management plans, manure value, land use and neighbor relations.

2. Brief description of the target audience

Michigan animal producers, agriculture and natural resources industry representatives, animal pharmaceutical industry, animal welfare organizations, state agency representatives, state and local elected officials and the interested public.

3. How was eXtension used?

MSU Extension continues to utilize eXtension as one of the primary multi-state activities that involve contributing to Communities of Practice, responding to Ask an Expert questions, and contributing to innovation projects. One example in this area was: Horse Quest and helping in the development of Equine Welfare chapter of the Horse Industry Handbook.

V(E). Planned Program (Outputs)

1. Standard output measures

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	2907	8721	17631	17631

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year: 2017

Actual: 2

Patents listed

MICL02434, Mechanism of Cellular Reprogramming During Somatic Cell Nuclear Transfer (SN 15/326,863); MICL02470, Molecular Mechanisms Associated with Turkey Skeletal Muscle Growth and Meat Quality (SN 62/443,998)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	0	41	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research programs on animal production and protection.

Year	Actual
2017	39

Output #2

Output Measure

- Number of adult participants trained in animal management systems.

Year	Actual
2017	2907

Output #3

Output Measure

- Number of youth participants trained in animal management systems.

Year	Actual
2017	17631

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of adult participants with increased knowledge about animal management systems.
2	Number of youth participants with increased knowledge about animal management systems.
3	Number of research programs to understand the processes that control/influence reproduction at the molecular and genetic level.
4	Number of research programs to add to the understanding of various food animal genomes by improving and integrating genetic maps.
5	Number of research programs to develop and evaluate new tools and strategies to detect, prevent and control emerging and reemerging livestock and poultry diseases.
6	Number of research programs to understand the environmental fate and biological effects of vaccines, steroids and other substances fed to animals.
7	Number of research programs to develop and evaluate management/training strategies for horses to reduce injuries.
8	Number of research programs to add to the understanding of animal behavior and welfare.
9	Number of research programs to test new cropping, grazing and feeding strategies for food animals.

Outcome #1

1. Outcome Measures

Number of adult participants with increased knowledge about animal management systems.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	2558

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example of an issue in this area for Michigan dairy farms is overmilking and bimodal (delayed milk let down). Preliminary data from Erskine and Moore-Foster (2016) indicates that in the top 25% of herds in their project, less than 10% of the cows have bimodal milking or are over milked. In contrast, 44% (28 of the 63 herds tested) experienced overmilking in over 30% of their cows. Furthermore, 10 of the 28 herds had over 60% of the cows being overmilked. This same research showed 29% (18 out of 63 herds tested) experienced bimodal in over 30% of their cows with 8 herds showing bimodal milking in over 50% of their cows. Damage to the teat end may occur when either bimodal or overmilking happen, discomfort for the cow increases, mastitis may increase and milking efficiency decreases.

What has been done
MSUE Interns working with Extension educators collected data from 20 farms across Michigan. This first data confirms the findings by Erskine/Moore-Foster. Our study takes this "education" around the problems one step further by asking farms if they will make a change(s) based on the initial findings, and then makes a second analysis visit to determine if the changes resulted in positive change in bimodal(delayed milk let down) milking and over milking.

Results
Twelve reports of the first analysis have been delivered to the farms. Of those asked "will you make a change based on this initial report", 11 of 12 indicated that they would make a change, and invited MSUE to come to the farm and do a follow-up evaluation. One second analysis has been conducted to date. This farm made a change in their milking protocol, resulting in a decrease in bimodal milking from 33% to 13% almost reaching the goal of less than 10% bimodal.

What difference did it make - public value? Reducing bimodal and overmilking improves milk quality and animal health. The public can be assured that Michigan producers participating in this

project are producing high quality milk while improving animal health/well being for their cows.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems
311	Animal Diseases

Outcome #2

1. Outcome Measures

Number of youth participants with increased knowledge about animal management systems.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	15515

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Youth need opportunities and information to learn about animal management systems and related science that will lead to improved life skills and help in exploring new careers.

What has been done
One example is MSUE hosted the Michigan 4-H Dairy Conference for youth and adults with the following objectives:

- Provide 4-H youth and adult leaders the opportunity to learn more about the Michigan dairy industry.
- Teach skills in areas of dairy science and management.
- To give conference participants opportunities to explore new ideas in-depth and get a ?hands-on? experience.

This workshop is open to youth (aged 13 and older) and adult leaders interested in dairy science, management, and judging. Participants had 15 contact hours with 5 dairy industry professionals, 4 MSUE Educators, 1 4-H Program Coordinator, 2 MSU faculty from the Department of Animal Science, 2 local dairy farmers, 1 dairy veterinarian specializing in reproductive technologies.

The attendees spent 3 days exploring ideas, research and hands-on activities relating to dairy science and biology. Youth and adult participants were given the opportunity to participate in a variety of sessions, including: dissecting a female reproductive tract, learning about embryo transfer, practicing artificial insemination on a preserved reproductive tract, and learning about dairy judging. During the farm visit, youth learned about linear scoring, dairy careers, and cow comfort.

Sponsorship made the event possible with funding from The American Dairy Association of Michigan and the Michigan Milk Producers Association.

Results
Evaluation results found 68 total participants attended - 18 males and 50 females representing 10 counties. 52 youth participated along with 16 adults. 40 (77% of participants) youth voluntarily submitted a retrospective post-then-pre evaluation of their experience at the conference.

- 75% of youth indicated positive attitudes and aspirations towards science after the conference compared to 68% before the conference.

- 93% of youth demonstrated a capacity for science process skills after the conference compared to 81% before the conference.

- 100% of youth indicated they were aware of the science skills learned in 4-H after the conference compared to 93% before the conference.

- 98% of youth could identify the science learned in 4-H after the conference compared to 78% before the conference.

- 87% of youth demonstrated the ability to make positive choices through responsibility, critical thinking, problem solving, informed decision making, flexibility, adaptability, and setting goals with a plan to reach them after the conference compared to 83% before the conference.

- 98% of youth indicted they were aware of the life skills learned in 4-H after the conference compared to 90% before the conference.

- 95% of youth could identify life skills learned in 4-H after the conference compared to 90% before the conference.

- 95% of youth were felt more knowledgeable about entrepreneurship and career opportunities in science-related fields compared to 75% before the conference.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems
311	Animal Diseases
806	Youth Development

Outcome #3

1. Outcome Measures

Number of research programs to understand the processes that control/influence reproduction at the molecular and genetic level.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Reproductive efficiency is a major determinant of the economic success of beef and dairy operations. For example, in the dairy industry, conception rates in lactating cows have decreased from 66% in 1951, to a less desirable level of 35% or less today. Poor conception rates have a detrimental impact on days open and increase reproductive culls form the herd Thus, total reproductive inefficiencies from culling and lost milk due to extended calving intervals account for significant economic loss to dairy producers (> $90 per cow) of over $2.4 billion annually. In domestic ruminants, embryonic and fetal death may account for up to 75% of all reproductive loss following a single breeding. The causes of infertility in beef and dairy cattle remain poorly understood but may be attributable in part to ovulation of eggs (oocytes) of poor developmental competence. Poor oocyte competence is also the major factor limiting efficiency of reproductive biotechnologies (in vitro embryo production and nuclear transfer/cloning) in bovine species. Acquisition of oocyte competence is controlled by the interaction of genetics, the hormonal environment and the intrafollicular microenvironment. Despite decades of research, the fundamental questions remain of what makes an egg good or bad and how to improve egg quality in a laboratory setting or on farm.

What has been done
Research to: understand the impact of animal agriculture on the modern society; develop new methods to improve fertility and reproductive efficiency in livestock; investigate potential effects of exposure to environmental contaminants in humans and animals, with an emphasis on reproductive performance; develop a local/regional pasture-based beef production system encompassing the entire beef production chain; and to assess the impact of Ovsynch on conception rates of lactating dairy cows.

Results

To investigate if the positive impact of follistatin on early embryonic development leads to a positive effect on post implantation development we generated IVF embryos from oocytes that were aspirated from high genetic merit heifers and xsorted semen from a single high genetic merit bull. These embryos were then cultured in the presence or absence of follistatin. After 7 d of culture single blastocysts from each treatment group were transferred into the uteri of recipient females (on 4 different commercial dairy farms) at d 7 post ovulation. Positive pregnancy diagnosis was confirmed on day 28 post ovulation by measurement of serum pregnancy associated glycoproteins. Results of the experiment showed no difference in pregnancy rates between follistatin treated and control embryos and no difference in the percent of pregnancies that resulted in a live birth. This was similar to the results of a trial done at MSU's beef cattle farm using slaughterhouse oocytes and unsorted semen. In that trial we again found no statistical difference between control and follistatin treated embryos (day 28 pregnancy diagnosis). Taken together these results suggest that there is little difference in the pregnancy rate between treated and control embryos and therefore that the embryotrophic effect of follistatin on early embryonic development
probably does not affect the post implantation development of IVF embryos.

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of Animals
303	Genetic Improvement of Animals
304	Animal Genome
305	Animal Physiological Processes
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals

Outcome #4

1. Outcome Measures

Number of research programs to add to the understanding of various food animal genomes by improving and integrating genetic maps.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Genetic maps are an integral part of several statistical models that are commonly used to find disease genes. A better understanding of these maps will allow for the development of increasingly accurate models that will provide researchers and producers with reliable estimates in a practical amount of time and will greatly enhance disease prevention and treatment efforts.

Dairy cattle production has been characterized by steady increases in milk production such that the United States (US) has transformed from a net importer to a net exporter of milk just over the past decade. But with recently depressed milk prices and profit margins, it is vitally important advance foundational research that will lead to the development of more balanced strategies for improving the economic efficiency of US dairy farms. These strategies need to consider a greater emphasis on novel traits characterizing dairy cattle fitness, fertility, and feed efficiency than what has been considered previously in order to ensure the economic and environmental sustainability of the US dairy industry. Already many other countries in Europe and Canada are somewhat ahead in implementing dairy genetic evaluation systems for these novel traits, thereby creating an even greater sense of urgency to spearhead such efforts within the US. However, it can be rather challenging and expensive to collect a
meaningfully large data resource on novel traits such that extensive, including international, collaboration is necessary.

What has been done

Research to: develop a new set of tools and reagents to study autologous cell therapy using a new large animal model; enhancing efficiency of lean growth, and improving quality and consistency of pork in swine breeding programs

Results

We have recently published a paper in the high impact journal Genetics which highlights the utility of hierarchical Bayesian modeling in conjunction with testing on genomic windows (i.e., joint tests on all genomic markers within a region rather than tests on individual markers themselves) to dramatically improve the sensitivity and specificity of genome wide association (GWA) inference relative to currently very popular strategies based on a standard normality assumption. That is, the hierarchical Bayesian approaches facilitate a wide range of distributional specification alternatives that more flexibly model genetic architecture for GWA studies. 1b) We currently have a paper under review (former graduate student Yongfang Lu) which utilizes both information on genotyped and non-genotyped animals for genome wide association inferences for feed efficiency and its component traits (dry matter intake, milk energy, and body weight).
Additionally we have a manuscript in preparation (former graduate student Chunyu Chen) whereby we extend the work described above under 1a) to allow for non-genotyped animals having records within a more powerful hierarchical Bayesian modeling framework. Both papers illustrate how important it can be to include phenotypic information on non-genotyped animals to improve GWA inferences.

4. Associated Knowledge Areas

KA Code	Knowledge Area

304 Animal Genome

305 Animal Physiological Processes

Outcome #5

1. Outcome Measures

Number of research programs to develop and evaluate new tools and strategies to detect, prevent and control emerging and reemerging livestock and poultry diseases.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	9

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

There are increasing public concerns about antimicrobial use in animals and the development, persistence, accumulation and dissemination of resistance in enteric bacteria of livestock origin and its implications for human health. These concerns have lead regulatory organizations around the world to promulgate rules to protect public health by either reducing the number and/or formulations of antimicrobial drugs available for use in food animal agriculture (e.g., the ban of antimicrobial growth promoters in the European Union) or by tightening the approval and monitoring processes for new antimicrobial drugs intended for food
animal use (e.g., FDA's Guidance for Industry #152 in the United States). Furthermore, the availability of currently efficacious
therapeutic antibiotics may be curtailed, as evidenced by the FDA proposed ban on all extralabel use of cephalosporins in food animals in 2008. The future costs to animal agriculture (and potentially to consumers and other stakeholders) will be tremendous if certain classes or uses of antibiotics are no longer available. The use of antibiotics for treatment and prevention of bacterial infections in beef and dairy cattle is essential for sustaining profitability in these two sectors, for producing safe and wholesome food for consumers, and for ensuring the maximum welfare of the animals. Discovering and sharing proven, responsible and prudent ways to make better use of both existing and new antibiotics - with minimal risk to human health - will not only reduce the costs associated with antibiotic resistance, but also promote a profitable and sustainable agriculture in the future. Additionally, the development of safe and efficacious alternatives to antibiotic treatments may help slow accumulation and dissemination of antimicrobial resistance in food animals.

What has been done

Research to: derive useful information on emerging infectious diseases; develop new interventions to reduce antimicrobial resistance when treating animals with antimicrobial drugs and develop a new non-antibiotic treatment option for mastitis in dairy cows; dissect the mechanism of representative members of enzymes; determine if discontinuing the use of milk replacer medicated with antibiotics results in increased antimicrobial susceptibility in enteric organisms; to elucidate the molecular mechanisms that control phenotypic variation in economically important pig production and meat quality traits; and understand the role of bovine leukemia virus (BLV)infection on progression of clinical Johnes disease.

Results

One of our previously reported findings has been that there is a smaller proportion of dry cows in which we can detect ceftiofur-resistant coliforms as compared to cows in other stages of their lactation cycle. We were curious about this finding because the farm at which we conducted the longitudinal study uses a ceftiofur product for intra-mammary dry-cow treatment, and we would expect that this might affect levels of ceftiofur-resistant coliforms in the feces of dry cows. Although, not a part of the original objective, we decided to investigate if dry-cow treatment with a ceftiofur product would affect the levels of ceftiofur-resistant coliform bacteria in cows treated intra-mammary with a ceftiofur product. Because this farm does
blanket treats all cows at dry-off, we did not have a control group consisting of cows not dry-treated and moved to the dry-cow pen with the dry-cow treated cows. However, we followed a group of cows that we to be dried off the following week, but who stayed in the pen the dry cows were in be they were dried off and moved to the dry-cow pen. The total coliform counts decreased by about 1 log concentration and ceftiofur-resistant coliform counts in dry cows increased by approximately half a log. These findings are similar to findings when cows are injected parentally with ceftiofur products. However, the effect was not as large. No changes were seen in the group of cows that were not dried off. Using a multiple singleplex qPCR platform
that allows us to quantitate over 100 resistance genes, we found that the gene coding for ceftiofur resistance (blaCMY-2) increased from less than 0.01% to over 0.1% in relative abundance as compared to cows that were not treated. Although, this finding cannot be definitively attributed to the effect of intra-mammary infusion of a ceftiofur product, it suggests that intramammary infusion of ceftiofur in dry cows, results in some systemic absorption of ceftiofur which in term affects the intestinal microbiome and resistome.

Horses have played an important role in the history of agriculture within the State of Michigan, and currently are a significant
source of economic activity in the state. Disease in horses can have a major negative impact on the equine industry, particularly those diseases that are poorly understood and which lack effective preventive and treatment measures. In 2007 we identified and described a new progressive equine pulmonary disease associated with infection with the equine gammaherpesvirus (gHV) EHV 5. The disease has a characteristic clinical presentation, typified by low-grade fever, progressive exercise intolerance, and radiographic evidence of nodular pulmonary densities. The pathology of the disease consists of severe nodular interstitial lung fibrosis. Because of the characteristic clinical, pathologic, and virologic findings of this previously unrecognized disease it was named equine multinodular pulmonary fibrosis (EMPF).

4. Associated Knowledge Areas

KA Code	Knowledge Area

303	Genetic Improvement of Animals
305	Animal Physiological Processes
308	Improved Animal Products (Before Harvest)
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection

Outcome #6

1. Outcome Measures

Number of research programs to understand the environmental fate and biological effects of vaccines, steroids and other substances fed to animals.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
In Michigan in the 1970s, the Michigan Chemical Company accidently replaced the cattle feed additive, FeedMaster (i.e. MgO) with FireMaster (i.e. polybromninate biphenols, PBBs) a fire retardant. This accident lead to the contamination of animal feed with PBB and almost decimated the dairy and cattle industry in Michigan and put thousands of Michigan residents in harms way. This is not an isolated incident, there have been accidental contamination of this type of planar aromatic hydrocarbons (PAHs) in Italy, Belgium and Japan, to name a few. More importantly, PAHs, such as 2,3,7,8- etrachlorodibenzo-p-dioxin (TCDD) and PBBs, are also released into our environment at alarming rates due to natural and chemical and industrial manufacturing, contaminating land, water, and the wildlife that inhabit it, most notable is fish. In fact, some of the highest levels of TCDD found in the environment were measured in the Tibawasee River, downstream of the Dow Chemical Plant in Midland Michigan. In addition, many PAHs are now prominent contaminants in fertilizers being used on farms and the production of these farm-ready fertilizers from biosolids and industrial sludge has been linked to decreased milk production, lower crop yields, and human illnesses. Therefore, understanding the mechanism of poisoning and linking exposure of PAHs to the toxic endpoints, is timely and very relevant to all aspects of farming and human health, especially in establishing the safe levels of residues in feed for livestock and poultry (KA 314. Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other
Hazards Affecting Animals). Complete characterization of the impact of PAHs on biological systems will give us the necessary tools to adequately assess the risk associated with exposure,

the severity of exposure and knowledge base to treat the pathology associated with exposure. Moreover, characterizing the basic toxicological properties, such as dose response relationship, of these toxicants will help regulators set safe environmental levels. Characterizing the mechanism, therefore, is important for animal and human health, food security, and the protection of the general public, workforce, and our livestock.

What has been done
Research to: develop models that better reflect the heterogeneity in effects of causal variants and their associations with high density genetic markers across the genome

Results
We have successfully shown that a portion of the cellular pool of the AHR can be found within the mitochondria (i.e. mitoAHR). More important, recently, we have demonstrated that the level of mitoAHR is cell-type specific. We have also demonstrated that decreased TOMM20 can impact the level of mitoAHR, suggesting this translocase is essential for mitoAHR trafficking. We have also demonstrated that treatment of microglia with AHR agonists, such as TCDD alter the expression of key microglial activation marker genes and impact the growth characteristics of the cells. Finally, the level of AHR is impacted by the activation state of these cells. More specifically, when the cells are unactivated, TCDD decrease growth rate and when
M1 activated, their growth is subtly enhanced in the presence of TCDD.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals
315	Animal Welfare/Well-Being and Protection

Outcome #7

1. Outcome Measures

Number of research programs to develop and evaluate management/training strategies for horses to reduce injuries.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual

2017 1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

In May of 1997, the Department of Animal Science at Michigan State University identified three programmatic thrusts of the department - two of which were "Nutrition and Developmental Biology" and "Animal Well-Being". By focusing on the management of athletic horses to reduce injuries and improve performance, these are being addressed with this project. While changes to our department's strategic plan have altered the title of these thrusts, they are still major research areas within our department. More notably, the research focus of this MAES project is of great importance to the equine industry. The major
problem facing individuals training horses for athletic competition is said to be keeping the horses free from injury (Hodgson and Rose, 1994). Performance horses routinely experience career-ending or career-altering injuries. Rossdale et al. (1985) determined that
lameness was the most common reason for racehorses to miss training. Johnson (1993) reported that, of horses necropsied as a result of death at a California racetrack, 84.6% had injuries to the musculoskeletal system. In addition, a British survey showed that 58.1% of two-year-olds became lame at some time during training (Jones, 1989). In the U.S., the problem encountered by young horses may be even greater. This is due to one of the more frequently witnessed disorders of young racehorses -- the bucked shin complex. Veterinarians working in the U.S. reported a 70% incidence of bucked shins in twoyear-old Thoroughbred racehorses (Norwood, 1978) and an incidence rate in two-year-old racing Quarter Horses of up to 50%
has been reported by Goodman (1987). Another common problem that can affect any athletic hrse, including racing, dressage, jumping or roping horses, is degenerative joint disease (Smith, 1991). Degeneration of the articular cartilage results from excessive stress that accompanies many equine athletic events (Baxter, 1992). The ensuing lameness can result in reduced performance and possibly even permanent joint dysfunction.

What has been done

Research to: examine whether omeprazole administration will alter calcium absorption, markers associated with bone mineral turnover, and health in athletic horses.

Results

We conducted a study to examine whether omeprazole (a proton-pump inhibitor) interferes with mineral absorption - potentially leaving horses prone to injury. Results from this study showed that two months of administration of omeprazole at the preventative dosage did not alter mineral absorption or appear to influence any factors associated with bone health - leaving omeprazole treatment of ulcers as the gold standard for treatment.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems
315	Animal Welfare/Well-Being and Protection

Outcome #8

1. Outcome Measures

Number of research programs to add to the understanding of animal behavior and welfare.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Our society has placed increased emphasis on the welfare of research and exhibit animals. U.S. law now requires attending to exercise requirements for dogs and the psychological well-being of non-human primates. Animal welfare without knowledge is impossible. Animal behavior researchers look at the behavior and well-being of animals in lab and field. Good animal welfare requires solid science that informs and directs policies and practices related to disease prevention and veterinary treatment, appropriate shelter, management, nutrition, humane handling and humane slaughter.

What has been done
Research to: maintain and improve skeletal health in livestock and companion animals; identify management practices and environmental conditions, particularly for young animals, that allow expression of positive natural behaviors while improving animal welfare in the context of environmentally sustainable production systems; and to examine ethical issues in agriculture.

Results
As a result of ongoing experiments related to the behavior and welfare of production animals, one outcome will be a change in our scientific knowledge related to the management of livestock. By relating social behavior phenotypes to genotypes in swine, we can allow breeding companies and producers to choose pigs for breeding that are suited to living in groups--which is increasingly important for reducing aggression and production losses as more pregnant sows move to group housing. Our improved knowledge of pig social behavior and how combinations of personalities or fighting styles affect aggression will allow us to better manage pigs in groups at all stages of production. In 2016-2017, research continued on a project examining the relationship between social behavioral phenotypes and underlying genotypes in group-housed pigs with support from USDA NIFA and previous support from the National Pork Board and the Rackham Foundation (internal to MSU). This is a collaboration with colleagues at Scotland's Rural College. Funding

was obtained in 2016-2017 from USDA NIFA Food Security Program and the Michigan Alliance for Animal
Agriculture (MAAA) with J. Siegford as co-PI. The team expanded to include researchers at University of Buenos Aires, Argentina and University of Leuven, Belgium. The aims are to better model indirect genetic effects in group-housed swine and use technology to automate detection of individuals and behavioral phenotypes.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems
315	Animal Welfare/Well-Being and Protection

Outcome #9

1. Outcome Measures

Number of research programs to test new cropping, grazing and feeding strategies for food animals.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	9

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
As production costs rise, environmental concerns increase and consumer expectations become higher, those involved in the agrifood industry are looking for ways to maximize reproductive and performance efficiencies in a way that is economically and environmentally sustainable, and that protects human and animal health.

What has been done
Research to: develop a local/regional pasture-based beef production system encompassing the entire beef production chain; investigate strategies to maximize milk production output and ecosystem functions in grazing dairy systems; mitigate the environmental footprint of animal systems; develop a local/regional pasture-based beef production system encompassing the entire beef production chain; investigate strategies to maximize production output (milk)and ecosystem functions (processes and services) in grazing systems managed under various scenarios for the optimization of automatic milking and pasture systems; better understand the mineral needs of the pig; and to evaluate the effectiveness of mannaniligosaccharides on egg production, egg

weight and bird livability of laying hens

Results

We have continued our studies determining the impact of of C16:0, C18:0, and C18:1 on production responses and nutrient digestibility as well as efficiency of feed conversion into milk. We reported the negative effects of increased C18:0 intake on nutrient digesitbility and production compared to increased dietary C16:0. We also reported the benefits of C16:0 on total tract NDF digesitbility and the potential for dietary C18:1 to improve total tract fatty acid digestibility. We extended these results to look at the impact of feeding C16:0 and C18:1 during early lactation on milk production, energy balance, and body weight loss. We have reported the potential for a C16:0 supplement to increase milk energy output during early lactation and during long term supplemetation in established lactation. We extended these results to examine the impact of diets with different ratios of C16:0 and C18:1 on milk fat synthesis, energy partitioning and body weight gain across differnet levels of milk production. Other research focused on in vitro batch culture techniques to examine the impact of rumen pH and dietary nutrients on production of biohydrogenation intermediates known to cause milk fat depression as well as the effect of long chain omega-6 and omega-3 fatty acids on immune function and reproduction.

4. Associated Knowledge Areas

KA Code	Knowledge Area
302	Nutrient Utilization in Animals
307	Animal Management Systems
308	Improved Animal Products (Before Harvest)

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

During the 2016-17 fiscal year, ABR and MSUE support many areas such as our Enviro-weather stations. To assist Michigan producers with pest, plant production and natural resource management decisions, Enviro-weather provides weather data from a network of stations located throughout the state. Enviro-weather data are shared with other weather groups across the region and are also used in college and university classrooms to teach students about topics such as weather, agriculture and pest management. Since the creation of the Enviro-weather program, data requests have grown from 96 on average per day to more than 450 in 2015.

Project GREEEN funds supported:

• Two tower stations added to the Enviro-weather network to provide real-time, cross-sectional temperature and wind information to fruit growers for monitoring low-level inversions and making decisions related to wind machine-based frost protection.
• Along with the two tower sites, three additional standard stations were added within the past year: Benona/Shelby, Michigan; Kewaunee, Wisconsin; and Grant, Michigan.
• Operational upgrades including strategic network and system modernization, as well as routine weather network maintenance.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

As Hatch dollars are base funding for faculty salaries, there is a built-in evaluation mechanism through annual reviews of overall performance, research productivity and the leveraging of additional research dollars. In addition, many of the research projects have an evaluative element that is required by state and federal-level funding sources that provides documentation related to project assumptions, goals and outcomes. This information is used to determine the overall success of the research initiatives; their contribution to providing practical, real-world solutions and resources to address challenges and problems; and whether continuation funding and/or new dollars are appropriate and necessary as funds are available.

Other examples of MSUE programs with evaluation results in this area are:

Focus on the First 24 Hours

Issue

The first 24 hours of a calf's life can significantly influence its longevity and productivity in the herd. Newborn calves must consume ample quantities of high quality colostrum shortly after birth to ensure successful passive transfer. The meeting will focus on the dam's ability to produce high quality colostrum based on vaccination protocols and nutritional management during the dry period. Other colostrum quality factors to be highlighted are timing of colostrum harvest (first milking) and avoiding bacterial contamination of colostrum. Managing the maternity pen to minimize stress for the cow and to provide a clean environment for the calf and the dam are critical. Learning ways to reduce stillbirths that include genetic selection and appropriate intervention during calving is important. In addition, techniques for handling the newborn calf to minimize any additional stress following birth and special considerations for handling calves during the winter are important.

Response

In 2017 MSU Extension hosted the dairy winter program that was designed for dairy farm owners, herd managers and agribusiness professionals to learn about the latest research and strategies to improve long-term health and growth of dairy replacements from the first day.

Results

Six presentations were given with 97 participants completing an evaluation. 55 indicated that as a result of the program they intended to change something on their operation, that included:
Improved Colostrum Quality/Management: 70% (38)
- Start testing colostrum: 32% (12)
- Increase volume fed: 21% (8)
- Improve timing of feeding: 21% (8)
- Improve storage/cooling: 21% (8)

Write/Improve Protocols: 11% (6)
Employee training: 11% (6)
Maternity Pen Improvements: 22% (12)
- Improve timing of moves: 33% (4)
- Install plywood to reduce stress: 17% (2)

Reduce Stillbirths: 7% (4)
Better Records of stillbirths and calving ease scores: 6% (3)
Improve calf health through sanitation and medication: 13% (7)
Build warming boxes: 4% (2)
Participants were also surveyed on increase of knowledge regarding each presentation on a scale of 1-5, with 5 being the highest change in knowledge. The 97 respondents answered as follows:
Managing for high quality colostrum: 4.3
Importance of Successful Passive Transfer: 4.1
Assessing Passive Transfer Status on MI Dairy Farms: 4.0
Maternity Pen Management: 4.0
Newborn Care and Handling: 3.9
Reducing Stillbirths: 3.9

Another example is:

Low Stress Animal Movement

Issue

It is important to continue to train employees in proper animal handling and treatment to keep the welfare standards high on dairy farms. The need was identified by the Michigan Milk Producers Association Field Staff and MSUE educators and specialists.

Response

MSU Extension implemented a training program to fill a need of employee training in the areas of low stress animal movement and down cow management. This training was provided to help farm owners, managers, employees learn how to safely handle animals in a low-stress environment. This training met the requirement for the FARM program annual training requirement. The training was taught by two instructors where one presented in English and the other in Spanish. This dual presentation was done in both the lecture and the demonstrations in the animal pens.

Results

Evaluation results found participants indicated high levels of change on a scale of 1 (low change) to 5 (high change):
Moving a down cow without causing further injury: 4.83
Properly handling cows: 4.6
Creating a low stress environment in the parlor: 4
Eight-three percent (83%) planned on making changes in how they handled thousands of cows. Specific changes included: slower movement, handle without stress(movements, loudness, and body language),sharing information with all employees so they understand why cows should be moved in stress free manner, less yelling, be gentle, watch flight zones, and don't put too much pressure on cow.

Key Items of Evaluation

MSU AgBioResearch
Improving genetic selection may hold key to peaceful pig grouping (https://tinyurl.com/yc2fjsqh)

Growing concern over the welfare of agricultural animals has led many states to pass legislation that mandates a fresh set of care practices. California did so in 2008, and many

others have followed suit.

In 2009, the Michigan Legislature passed an amendment to the Animal Industry Act introducing a series of new standards for gestating sows, laying hens and veal calves. Included is the requirement of additional living space for gestating sows. By April 1, 2020, all producers will need to house pregnant pigs in stalls where they can turn about freely, something typically not found in most current operations.

The majority of agricultural producers don't have the physical capacity to give each sow an individual pen. And though pigs are social by nature, they don't always get along well in group settings. Researchers at Michigan State University (MSU) and Scotland's Rural College are looking for ways to place pigs so they are more likely to live in harmony together. The basis for the solution may be rooted in genetics.

"Being cognizant of how we treat animals is a great thing, and the new standards sound really good in principle," said Janice Siegford, an MSU associate professor of animal science who's working on the five-year project. "But pigs are currently being selected for breeding with no respect to how they perform in social situations. There's a lot of evolutionary history that says it's best if the animals know each other and are raised together, but that's not often what is done in practice."

MSU Extension

- 2,907 adults were trained on animal management systems
- 961 adults were trained on Beef
- 681 adults were trained on Dairy
- 505 adults were trained on Employer/Employee Training Programs for Animal Production
- 427 adults were trained on Pork
- 321 adults were trained on Feed, Forage, and Grazing Management
- 320 adults were trained on Production Risk Management for Animal Production
- 204 adults were trained on Environmental Quality - Water Quality as it relates to animal production
- 170 adults were trained on Equine

V(A). Planned Program (Summary)

Program # 6

1. Name of the Planned Program

Food and Non-Food Quality, Nutrition, Engineering and Processing

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
205	Plant Management Systems	0%		10%	
402	Engineering Systems and Equipment	0%		12%	
501	New and Improved Food Processing Technologies	0%		12%	
502	New and Improved Food Products	0%		12%	
503	Quality Maintenance in Storing and Marketing Food Products	0%		12%	
504	Home and Commercial Food Service	0%		10%	
511	New and Improved Non-Food Products and Processes	20%		12%	
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins	80%		20%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	5.1	0.0	6.0	0.0
Actual Paid	2.9	0.0	7.0	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
118334	0	482035	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
118334	0	503623	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	3106078	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Activities will be undertaken to:

- Connect Michigan industries with the research, education and entreprenuerial activity needed in the basic sciences, engineering, plant science and agriculture to provide the state with a foundation for the vigorous development of a strong biobased economic sector.
- Identify and isolate beneficial plant compounds and develop technologies and processes to make new functional foods.
- Develop new biosensors and DNA chips that can rapidly and accurately detect a broad spectrum of harmful organisms in food and water.
- Identify breeding and genetic improvements related to food quality, nutrition and processing.
- Develop packaging systems to enhance food quality and shelf life.

2. Brief description of the target audience

Agriculture and natural resources industry representatives, biotechnology company representatives, food industry representatives,state agency representatives, private citizens, entreprenuers, native American growers.

3. How was eXtension used?

MSU Extension continues to utilize eXtension as one of the primary multi-state activities that involve contributing to Communities of Practice, responding to Ask an Expert questions, and contributing to innovation projects. One example in this area was: A food bank made an inquiry about food safety requirements for organizations creating food packets using bulk-packaged foods.

V(E). Planned Program (Outputs)

1. Standard output measures

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	0	0	0	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2017
Actual:	3

Patents listed

MICL02007, Field-Operable Nano-Biosensors for Global Health, Biodefense, Food Safety, and Water Quality (SN 62/381,979); MICL02291 Bioreactor Engineering for Gas-Intensive Fermentations to Produce Biobased Fuels and Chemicals (SN 15/383,320); MICL02308, Improving biofuel crops by targeting biosynthesis and storage of mixed-linkage glucan in stem parenchyma tissue of model grasses (SN 15/237,331)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	0	23	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research projects focusing on food quality, nutrition, engineering and processing.

Year	Actual
2017	21

Output #2

Output Measure

- Number of adults trained on new and improved non-food and bioeconomy related products and processes.
  Not reporting on this Output for this Annual Report

Output #3

Output Measure

- Number of food handlers that increase their knowledge about food safety.

Year	Actual
2017	1861

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of research programs to identify and isolate plant compounds and/or develop processes and technologies to manufacture functional foods.
2	Number of research programs to develop new biosensors and DNA chips that can rapidly and accurately detect a broad spectrum of harmful organisms in food and water.
3	Number of research programs to identify breeding and genetic improvement related to food quality, nutrition and processing.
4	Number of research programs to develop packaging systems to enhance food quality and shelf life.
5	Number of research programs to connect Michigan industries with research, education and entrepreneurial activity needed in the basic sciences, engineering and plant science and agriculture to provide the state with a foundation for vigorous development of a strong biobased economic sector.
6	Number of food handlers that increased their knowledge about food safety.

Outcome #1

1. Outcome Measures

Number of research programs to identify and isolate plant compounds and/or develop processes and technologies to manufacture functional foods.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Dwindling farm acreage, more expensive production and processing costs, and increased consumer expectations have prompted research into creating new - and enhancing existing - processes and technologies that manufacture healthy, functional foods. More significant, perhaps, is the potential of functional foods to mitigate disease, promote health and reduce health care costs.

What has been done
Research to: identify, develop means to potentially increase labor efficiency or reduce labor requirements; to more consciously utilize and protect natural resources; and to maximize quality and consistency of product through development and implementation of sensing and automation technology and through effective harvest and post harvest handling methods in the fruit, vegetable, and chestnut industries; provide comprehensive, well designed, scientifically sound studies that compare organic milk to conventional milk by tracking milk production from comparable farms, processed under similar conditions, and handled similarly until it reaches the consumer.

Results
A new revolutionized approach to more uniformly and more efficiently cool tart cherries has been successfully developed with grower cooperation and continues to see expanded implementation but needs continued improved transfer of information and design to the industry.

4. Associated Knowledge Areas

KA Code	Knowledge Area
501	New and Improved Food Processing Technologies

502	New and Improved Food Products
503	Quality Maintenance in Storing and Marketing Food Products

Outcome #2

1. Outcome Measures

Number of research programs to develop new biosensors and DNA chips that can rapidly and accurately detect a broad spectrum of harmful organisms in food and water.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The rapid detection of harmful organisms and disease-causing agents in food and water, and the ability to track and trace sources is critical to human health. In the food safety arena, it is estimated that 48 million food-borne illnesses occur each year in the U.S., accounting for 128,000 hospitalizations and more than 3,000 deaths. Biosensors can play a key role in food safety by quickly identifying contaminants in water supplies, food processing and assembly lines, raw food materials and food products before they cause problems further up the food chain.

What has been done
Research to: develop novel field-operable biosensors for rapid detection of bacterial pathogens of concern to global health, biodefense, food safety, and water quality; understand newly identified mechanisms by which foodborne toxins disrupt normal function of specialized hormone-secreting cells in the gut and elicit anorexia and vomiting.

Results
Synthesized and characterized functionalized magnetic nanoparticles (MNP) for rapid extraction and capture of bacterial contaminants in food and water. We have also synthesized gold nanoparticles for signal generation in biosensor devices.These MNPs were used to extract different types of bacteria, such E. coli, Salmonella, Listeria, Bacillus, and Vibrio in phosphate buffer and in complex food matrices. The food matrices included milk (whole, 2%, 1%, and skim), egg, egg yolk, mayonnaise, apple juice, lettuce, sprouts, and fish. These were also used to extract microbial contaminants in wastewater and
river water. We also synthesized gold nanoparticles (AuNP), cadium sulfide nanoparticles (CdS), and lead sulfide nanoparticles (PbS) for signal generation.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment
503	Quality Maintenance in Storing and Marketing Food Products

Outcome #3

1. Outcome Measures

Number of research programs to identify breeding and genetic improvement related to food quality, nutrition and processing.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	6

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Genetic diversity is required to meet certain production needs in plant and animal agriculture to allow for sustained genetic improvement and to facilitate rapid adaptation to changing breeding objectives. Recent efforts in gene discovery and functional genomics are providing the necessary understanding to develop and evaluate different approaches to manipulate phytochemical composition

What has been done
Research to: determine the impact of heat stress on meat quality; help address the detection and diagnostic challenges in global health, biodefense and food/water safety; assess the risk of humans to mycotoxins via food-borne and air-borne exposure and develop appropriate mitigation strategies; understand the process of E. coli chromosomal DNA replication and its regulation at the biochemical level; identify protein markers that are indicators for soft wheat processing quality; limit human exposure to aflatoxin in food to help prevent liver cancer; characterize the role of hypoxia in metal-induced toxicity; and to develop innovative processing that adds value to fresh or processed meat products.

Results
Developed several novel approaches to prevent aflatoxin in crops mostly focused on natural products isolated from plants,
fungi, and lichens.

The results from this past year have continued to support the premise that low-moisture pasteurization processes need to be validated for different types of products, given that efficacy can be affected by product structure, water activity, etc. Therefore, it is extremely important to use product-specific inactivation parameters, as developed in this project, when validating pasteurization processes.

4. Associated Knowledge Areas

KA Code	Knowledge Area
501	New and Improved Food Processing Technologies
502	New and Improved Food Products

Outcome #4

1. Outcome Measures

Number of research programs to develop packaging systems to enhance food quality and shelf life.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Consumption of fruits and vegetables has rapidly increased in recent years due to their associated health benefits. Specifically, fresh-cut fruits and vegetables are an important growing segment of the U.S. food industry since consumers seek for healthy, ready-to-eat food. In 2012, the U.S. fresh-cut produce market was estimated to surpass $27 billion. Fresh-cut fruit retail sales increased by 10.3%, while fresh-cut vegetable retail sales increased by 5.5% from 2012 to 2013. The market for whole and fresh-cut produce continues to grow as consumers continue to seek healthy food.
Fresh produce is one of the most perishable types of food since it cannot be processed (e.g., sterilization) to slow down physiological and microbial deterioration, unlike most other types of food. Furthermore, the transformation of whole fresh produce into fresh-cut products results in a highly perishable food with a very short shelf life. Additionally, the increasing number of foodborne outbreaks related to fresh-cut produce makes the control of foodborne pathogens in this sector a key to preventing a major public health problem.
As a result of physiological and microbial deterioration occurring during storage and marketing of

fresh produce, and especially fresh-cut produce, there is a need to develop effective technologies for maintaining the quality (appearance, flavor, texture, nutritional value) and food safety of whole and fresh-cut produce. Thus, the fresh produce industry is constantly seeking ways to extend the marketability of its products and also striving to match the needs of modern consumers.

What has been done
Research to: Promote functional and sustainable packaging systems that optimize the utilization of raw materials; to develop and use new types of packaging systems for fruits and vegetables; use nanoparticles in active packaging; and improve health through packaging.

Results
One study is working on building the active surface by immobilizing an active ingredient such as a bactericide on a nanoparticle, specifically MMT, which is fully dispersed (exfoliated) throughout the coating which will become a self-disinfecting surface.

In another study, determination of the effects of sachet presence on consumer product perception and active packaging acceptability - a study of fresh-cut cantaloupe (Christopher Wilson, Janice Harte, Eva Almenar). The impact of a visible
sachet inside of a package containing food on the consumer acceptance of the package and product perception was investigated. This study indicates that initiatives to develop active packaging for fresh-cut produce should focus on delivering active compounds in a manner not apparent to consumers.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment
503	Quality Maintenance in Storing and Marketing Food Products

Outcome #5

1. Outcome Measures

Number of research programs to connect Michigan industries with research, education and entrepreneurial activity needed in the basic sciences, engineering and plant science and agriculture to provide the state with a foundation for vigorous development of a strong biobased economic sector.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	6

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Plants are currently the only renewable source of carbon capable of displacing significant quantities of fossil fuels. However, the amount of plant matter expected to be available by the year 2030 is insufficient to displace even half of the current petroleum usage in the U.S., notwithstanding coal usage. Therefore, technologies that efficiently transform carbon into energy products are necessary. Biomass pyrolysis offers such an approach as both the carbohydrate and lignin fractions of biomass are converted to the liquid fuel intermediate known as bio-oil. As bio-oil bulk and energy densities are significantly greater than raw biomass, the decentralization of bioenergy systems using pyrolysis offers many advantages. However, bio-oil is characterized by reactive instability and corrosiveness which pose major barriers to adopting pyrolysis. At MSU, the
subsequent use of electrocatalysis has been studies to transform the reactive chemical species in bio-oil into stable forms. In so doing, bio-oil becomes less corrosive and hence more compatible with metal storage tanks and pipe networks. Transporting stable bio-oil to centralized refineries for more rigorous hydroprocessing to liquid hydrocarbon fuels then becomes feasible. The net outcome of this research is a carbon and energy efficient, liquid fuel bioenergy system, based on pyrolysis and electrocatalysis at regional depots followed by high temperature and pressure upgrading at centralized refineries.

What has been done

Research to: develop innovative bioelectrocatalytic converters that achieve mediated electron transfer to dehydrogenases and optimize the reactor's performance for coupled bioconversions having commercialization potential; and to facilitate the development of bio-derived fuels and chemicals through property characterization

Results

Electrocatalytic hydrogenation was shown to reduce such monoaromatic molecules as phenol, guaiacol and syringol. Phenolic dimers, such as 4-phenoxyphenol, were also cleaved to ultimately form cyclohexanol. In this reporting period, actual lignin dimers have been cleaved to demonstrate this technology's ability to upgrade lignin-derived bio-oil. A new technique for making the catalytic cathodes used for saturating bio-oils was investigated. This technique requires only mild conditions and does not produce gaseous hydrochloric acid as a by-product, which is corrosive to metal containers. This technique of preparing cathodes could be implemented within small-sca le pyrolysis depots, which is important for reducing costs in these facilities.
Whole bio-oil, derived from poplar, was also subjected to electrocatalytic reduction. Generally, several compounds within biooil
become saturated, in an analogous manner as was observed in our model compound studies. Data from these experiments will be used to inform energy analyses, technoeconomic analysis and life cycle assessment. In this reporting period, whole bio-oils were electrocatalytically reduced to create a liquid stream with a higher fuel value.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment
501	New and Improved Food Processing Technologies
503	Quality Maintenance in Storing and Marketing Food Products
511	New and Improved Non-Food Products and Processes

Outcome #6

1. Outcome Measures

Number of food handlers that increased their knowledge about food safety.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	1637

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example in this area is where the National Restaurant Association has documented the need and importance of teaching and certifying responsible food service providers. Food handlers not only need skills regarding food safety but need to stay on top of the various and changing regulatory requirements.

What has been done
Michigan State University Extension offers ServSafe, a national certification program for those working in food service. ServSafe teaches about foodborne illness, how to prevent it, and how to train employees on the latest food safety issues. The MSU Extension course provides participants education to successfully pass the Managers Certification exam. The ServSafe Manager course uses proven techniques, provides new Food and Drug Administration food code rules and content related to the food industry. Topics include: providing safe food, forms of contamination, the safe food handler, the flow of food, food safety management systems, safe facilities & pest management, cleaning & sanitizing.

Results
During 2017, MSU Extension helped 1,208 people complete training in 16 hours (68%), 8 hours (26%), or 4 hours (6%). The ServSafe program reached residents in 73 Michigan counties by 12 educators. Evaluation results found 83% of participants passed the exam with an average passing score of 82%.

4. Associated Knowledge Areas

KA Code	Knowledge Area
504	Home and Commercial Food Service

712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

During the 2016-17 fiscal year, ABR and MSUE support many areas such as our Enviro-weather stations. To assist Michigan producers with pest, plant production and natural resource management decisions, Enviro-weather provides weather data from a network of stations located throughout the state. Enviro-weather data are shared with other weather groups across the region and are also used in college and university classrooms to teach students about topics such as weather, agriculture and pest management. Since the creation of the Enviro-weather program, data requests have grown from 96 on average per day to more than 450 in 2015.

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- Along with the two tower sites, three additional standard stations were added within the past year: Benona/Shelby, Michigan; Kewaunee, Wisconsin; and Grant, Michigan.
- Operational upgrades including strategic network and system modernization, as well as routine weather network maintenance.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

As Hatch dollars are base funding for faculty salaries, there is a built-in evaluation mechanism through annual reviews of overall performance, research productivity and the leveraging of additional research dollars. In addition, many of the research projects have an evaluative element that is required by state and federal-level funding sources that provides documentation related to project assumptions, goals and outcomes. This information is used to determine the overall success of the research initiatives; their contribution to providing practical, real-world solutions and resources to address challenges and problems; and whether continuation funding and/or new dollars are appropriate and necessary as funds are available.

Other MSU Extension examples of evaluation results include:

Preparing underserved and minority berry growers for 3rd Party Good Agricultural Practices Audits under the new FSMA

Issue (who cares and why)?

There are approximately 86 Latino small blueberry growers registered in our MSUE date base. Those growers farm on average 12 acres of blueberries with an average yield of 3,000 lb/acre. Only a few of them are GAP certified and most are at risk of having their fruit rejected by buyers when they are required to show proof of GAP certification. With the implementation of FSMA final ruling, the GAP program that until 2015 was a volunteer program is becoming mandatory. Blueberry growers have to comply with all new regulations within the next 2 to 4 years after the date of the final ruling. And, the most at risk of failing to comply are FSMA exempt growers or those with less than $250,000 in annual sales. Most Latino blueberry growers are in these categories.

Although the ruling provides exceptions and grace periods for small farms, for many small producers compliance is an insurmountable obstacle jeopardizing the sustainability of their farms. Latino growers are the most affected by these new regulations due to lack of economic resources to hire technical assistance to meet the new food safety standards. Also, language and educational barriers make it very difficult for them to access information and assistance through traditional communication channels, such as MSU Extension websites, informational meetings and trainings provided by buyers and other third party sources of GAP information.

What has been done?

The Specific objective of this project was to develop and implement two 2-day training programs to help Latino growers and other underserved growers to obtain GAP (Good Agricultural Practices) certification or show proof of GAP compliance upon buyer's request.

To accomplish these objectives, two workshops were delivered; June 3 & 4, 2016 in Spanish and June 17 & 18; delivered in both Spanish and English. A total of 31 non-repeat participants attended the workshops. Because of the personalized approach to training and the in-depth hands-on assistance provided to participants, our intentions were to limit the number of trainees to no more than 15 per workshop. However, because of the demand for these trainings we had to exceed that number. Fortunately, we could still offer them a personalized training during both classroom and hands-on practice.

Workshops had a ½ day classroom session and 1 whole-day for on-farm hands-on training. The MSUE Blueberry GAP curriculum and a template manual that has been developed specifically for training were used to teach growers. All classroom PowerPoint presentations had notes under each slide to serve trainees as further reference.

Topics covered for the classroom training on the first day were: a) Introduction to GAP to Minimize Food Safety Issues; b) Blueberry Pre and Post -harvest Microbial Contamination; c) Worker Health and Hygiene; d) Field Sanitation and e) Water Quality. On Day 2 during the hands-on training we used the USDA GAP Harmonized Checklist.

Topics covered and practiced during this practical training were: How to conduct a risk Assessment at their own farms using the Checklist and how to write their own Food Safety Manuals.

During the hands-on sessions, growers received one-on-one assistance to start writing their Food Safety Manuals, and when at the farms were divided into groups that had to conduct risk assessments and report back findings to the whole group.

During training, growers received copies of training PowerPoint Presentations. For Spanish speakers, training PowerPoint presentations with notes were translated into Spanish from materials already developed in English.

Upon completion of the two-day workshops all trainees received a "Certificate of Completion of Training" as proof of GAP training. This Certificate can be shown as proof of GAP training if asked by their buyer's.

This training was attended by 31 non-repeated participants which included 5 Caucasian males and 26 Hispanics (2 females and 24 males). Counties served were: Allegan (10); Berrien (1), Ottawa (8) and Van Buren (12).

Results/Impact

Short-term.

• The Short-term proposal impacts were to have trainees develop their Food Safety manuals, conduct a Risk Assessment at their farms, initiate development of water standards, and show proof of GAP training upon buyers' request. The after training evaluation indicated that 54% of trainees developed their Food Safety Manuals, and 82% conducted their own Risk Assessments at their farms. Also, 54% developed water standards or tested their irrigation water for microbial contamination. **And most importantly**, 76% of trainees were able to show proof of GAP training when required by buyers. Although 83% sold their crop without problems 17% were not able to sell without proof of GAP training or Certification.

Long-term.

BEHAVIOR CHANGE & OUTCOME INDICATORS:

• Growers will obtain GAP certification or show proof of GAP compliance upon buyer's request.

• One year after training we expect 90% growers will have developed their Food Safety manuals, calculated their water standards and will have obtained GAP certification.

What difference did it make - public value?

This outreach program benefited 532 acres with an estimated production of 2,009,000 pound of blueberries. Considering the average price of blueberries in 2016 ($0.35/pound), the economic impact of this proposal was estimated in $703,150.

Another example is:

Cooking for Crowds

Issue

Many non-professionals prepare food for large group of people with limited understanding and skills in food safety.

Response

MSU Extension developed Cooking for Crowds for people that work or volunteer at non-profit organizations and who prepare food for the public or groups. This curriculum, developed by Penn State Cooperative Extension Service, is designed to educate non-profit groups about the risks that may occur when cooking large quantities of food. Strategies in Cooking for Crowds have been translated to fit the needs of groups such as churches and community organizations. Participants learn to prevent unsafe conditions that may cause foodborne illness during food planning, purchasing, storage, preparing and serving. By the end of the program, participants are able to identify unsafe conditions and safely plan for the food preparation and service at future community events.

Results

In 2017, Cooking for Crowds was a three-hour program that reached 199 participants in 11 counties. Program length varied 120 to 180 minutes. Evaluation results found:

Percentage of participants gaining new information Food Safety Knowledge

- 41% Personal Hygiene
- 84% Controlling Time & Temperature
- 63% Cross Contamination
- 71% Cleaning & Sanitizing
- 84% Foodborne Pathogens

Percentage of participants that gained skills on food safety practice:
- 70% Check food temperature with a calibrated food thermometer
- 53% Cook foods to proper temperature
- 34% Wash hands for 20 seconds
- 75% Limit the time food spends in the temperature danger zone
- 72% Cool foods quickly (to 70ºF in 2 hours and to 40ºF in 4 hours)
- 29% Separate raw and ready-to-eat foods during preparation, storage and serving
- 61% Use appropriate strength sanitizer on utensils, equipment & food contact surfaces

A three months follow-up found, on an average 199 individuals were served food by each program participant, for a total of 21,921 people served food by program participants in the last three months.

Key Items of Evaluation

MSU AgBioResearch

A New Frontier (https://tinyurl.com/y9awy9su)

Growing food crops is tough.

From constantly fluctuating temperatures and weather conditions to increasingly damaging pests and plant diseases, the odds are often stacked against a productive growing season.

Add in the pressure of meeting heavy market demand, and you have a recipe for anxiety. It's only natural that growers want to get out in front of these obstacles as much as possible, deploying the latest technology to ensure a profitable endeavor.

And while farming is big business with big challenges, the key to greater effectiveness in the field may come from something only seen with a powerful microscope.

Nanotechnology has been a topic of conversation in the scientific sphere for decades, but only recently has it forayed into agriculture. It involves the manipulation of materials at the atomic and molecular levels to perform a desired task.

Nanoparticles currently appear in cosmetics, clothing, paint and many other products for a variety of reasons, including their antimicrobial properties. The market value of nanotechnology products is expected to surpass $4 trillion by 2018.

In agriculture, nanotechnology has been developed in the form of nanocapsules for application of both pesticides and fertilizers.

Additionally, nanosensors monitor soil and plant health. Although not widespread in use yet, agricultural nanotechnologies are on the cutting edge of innovation.

"This is really amazing technology that can be revolutionary for the agriculture industry," said Wei Zhang, an assistant professor in the Department of Plant, Soil and Microbial Sciences at Michigan State University (MSU). "But it doesn't come without questions or concerns. These are brand new technologies in some cases, and because they are becoming more pervasive, we need to learn more about them."

Zhang is leading an MSU research team studying engineered nanoparticles (ENPs) as an emerging environmental contaminant. As more products employ nanotechnology -- particularly in agriculture -- the concentration of ENPs released into the environment will increase.

Testing for food toxin in U.S. grocery store items

Michigan State University researcher Felicia Wu has worked on investigating a food toxin known as aflatoxin.

In hot, humid regions of the world, a food toxin known as aflatoxin is produced by molds that contaminate crops. Aflatoxin can cause liver cancer, child stunting and immune system dysfunction. MSU scientist Felicia Wu has devoted much of her career to investigating aflatoxin, which

occurs most often in corn, peanuts and tree nuts.
The bulk of her work takes place in Africa, but Wu is also interested in digging into food safety closer to home.
From 2012 to 2014, Wu and a research team performed a risk assessment by testing for the presence of another fungal toxin, ochratoxin A (OTA), in items plucked directly off of U.S. grocery store shelves -- the first study of its kind in the country. Like aflatoxin, OTA has been associated with health risks. In a variety of animal species, kidney diseases and renal cancer have been linked to the toxin.

- Nearly 2,300 samples were selected from nine locations spanning the continental U.S. Foods included in the study - dried fruits, nuts, cereals, infant formula, wine, milk, coffee, cocoa and pork - were those likely to have detectable OTA. Organic, nonorganic and imported foods were represented.
- Results showed there is a negligible risk to Americans from OTA exposure.

MSU Extension
- 9,179 adults were trained by the Food Safety Work Team
- 4,285 One time presentation using approved food safety curriculum
- 2,063 Food Preservation series for youth or adults
- 1,171 ServSafe 16 or 8 hour sessions
- 618 Good Agricultural Practices and/or FSMA Produce Rule Grower Trainings
- 366 Cottage Food Law
- 324 ServSafe - 4 hour sessions for youth or adults
- 153 Food Pantry Program
- 199 Cooking for Crowds presentations

In addition, the Nutrition and Physical Activity Work Team incorporated food safety into their workshops that reached 48,096 adults

VI. National Outcomes and Indicators

1. NIFA Selected Outcomes and Indicators

Childhood Obesity (Outcome 1, Indicator 1.c)	
0	Number of children and youth who reported eating more of healthy foods.
Climate Change (Outcome 1, Indicator 4)	
0	Number of new crop varieties, animal breeds, and genotypes whit climate adaptive traits.
Global Food Security and Hunger (Outcome 1, Indicator 4.a)	
0	Number of participants adopting best practices and technologies resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources.
Global Food Security and Hunger (Outcome 2, Indicator 1)	
0	Number of new or improved innovations developed for food enterprises.
Food Safety (Outcome 1, Indicator 1)	
0	Number of viable technologies developed or modified for the detection and
Sustainable Energy (Outcome 3, Indicator 2)	
0	Number of farmers who adopted a dedicated bioenergy crop
Sustainable Energy (Outcome 3, Indicator 4)	
0	Tons of feedstocks delivered.