2016 Michigan State University Combined Research and Extension Annual Report of Accomplishments and Results

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I. Report Overview

1. Executive Summary

The need for targeted research and outreach in the areas of agriculture and natural resources has arguably never been higher than it is today. With emerging threats such as antibiotic resistance, bovine leukemia, invasive pests and avian influenza, agriculture producers are faced with a plethora of on-farm issues, many of which have human health implications. This, at a time, when the growing world population is projected to exceed 9 billion by 2050 and requiring our global food supply to double within that same timespan.

Michigan State University (MSU) AgBioResearch (ABR) scientists and MSU Extension (MSUE) specialists are valued for providing science-based knowledge in an effort to improve food and quality of life, as well as generate economic viability and sustainable practices. They are committed to helping to find solutions to meet growing food demands with fewer resources.

ABR conducts leading-edge research that combines scientific expertise with an understanding of real-world problems in the key areas of **FOOD**, **ENERGY** 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 years after its formation.

Also a vital component of the land grant mission, Michigan State University Extension (MSUE) disseminates the research knowledge to people in an effort 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.

Every dollar the state invested in ABR and MSUE in 2015-16 resulted in an additional $2.84 in federal funds and external contracts, grants and other revenues to serve Michigan residents. During that fiscal year, ABR secured $92.2 million in external contracts and grants from such federal agencies as the U.S. Department of Agriculture (USDA), National Science Foundation (NSF) and the U.S. Agency for International Development.

In the FY2015-2016, **the state's $60.5 million investment in ABR and MSUE generated more than $1 billion for Michigan residents**. The state's investment also allows ABR to secure external, competitive funds - further leveraging state dollars while creating opportunities to make discoveries that advance Michigan agriculture and sustain our natural resources.

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.

Quick Facts about MSU Extension
149,536 adults (shown below) and 212,776 youth were trained in MSUE's four Institutes and 27 Work Teams. 2016 MSUE State Plan with Work Teams Plans of Work can be viewed at https://reporting.anr.msu.edu/miprs2016/stateplan2016.pdf**.**

Institute for Agriculture and Agribusiness

- 4,214 AABI-01-Animal
- 1,776 AABI-02. Business Management
- 10,659 AABI-03-Consumer Horticulture
- 8,417 AABI-04-Field Crops
- 3,484 AABI-05-Fruit
- 1,843 AABI-06-Ornamental Horticulture
- 1,785 AABI-07-Vegetable
- 16,280 Public Event, Breakfast on the Farm, Ag Literacy, Consumer Ed, etc.
- 48,458 Total for Agriculture and Agribusiness

Institute for Children and Youth*

- 5,150 Academic Success
- 2,714 Capacity Building
- 552 Career Education/Work Force Preparation
- 1,390 Leadership & Civic Engagement
- 4,032 Michigan 4-H Youth Development
- 13,838 Total for Children and Youth

Institute for Greening Michigan

- 6,594 GM-1. Community Food Systems
- 3,547 GM-2. Natural Resources Stewardship
- 2,505 GM-3. Government and Public Policy
- 423 GM-4. Entrepreneurship
- 5,781 GM-5. Michigan Sea Grant
- 4,663 GM-6-Finance/Homeownership Education
- 509 GM-7-Leadership and Community Engagement (LCE)
- 243 GM-8-Tourism
- 24,265 Total for Greening Michigan

I**nstitute for Health and Nutrition**

- 3,051 HN-1. Disease Prevention and Management
- 6,456 HN-2. Food Safety
- 48,096 HN-3. Nutrition and Physical Activity
- 5,130 HN-4. Promoting social and emotional well-being
- 242 HN-5. Extension Health Research
- 62,975 Total for Health and Nutrition

* In 4-H there were 12,643 adult volunteers in 2016. In addition, 212,776 youth were involved in 4-H in 2016.

Examples of MSUE Impacts include:
Year-to-year increase using most recently available data:

- 37.5% increase in connections made by MSU Extension
- 4.2% increase in adult participation in MSU Extension programs
- 11.5% increase in youth participation in MSU Extension programs
- 48% increase in MSU Extension website visits
- 35.9% increase in MSU Extension website page views
- 55.8% increase in MSU Extension website visits from Michigan
- 73% increase in sign-ups for topic newsletter distribution

Agriculture

- $2,266,000 in $ new investment
- 460,598 # of acres adopting practices to increase yield, improve quality, or decrease inputs
- 107,878 # of acres adopting practices or tools that manage risks
- 66,528 # of acres adopting tools or technology to increase yield, improve quality, or decrease inputs
- 9,804 # of new acres under irrigation management

Early Childhood

• 90% said they increased their knowledge of techniques that help young children learn and promote school readiness.
• 85% indicated an increase in knowledge regarding basic concepts of early childhood development.
• 80% reported an increase in knowledge of how to keep children safe physically, emotionally and socially.
• 40% indicated the program would help reduce the number of times they do not know what to do as a parent.

Health

• 79% of youth participants improved their abilities or gained knowledge about how to choose foods according to Federal Dietary Guidelines.
• 79% of adult participants made a positive change in at least one nutrition practice, such as preparing foods without adding salt, or using the Nutrition Facts labels to make food choices.
• 73% of adult participants made a positive change in at least one food resource management practice, such as planning meals in advance or comparing prices when shopping.

Environment

• 82% of those responding to the survey felt that their knowledge had increased significantly in plants, soil, and environment.
• 76% reported significantly increased knowledge about environmental stewardship practices and IPM practices.
• 95% felt confident that they would be able to find answers to environmental questions.

Youth
More than 24,000 4-H youth participated in animal, biological and plant science projects in 78 counties. More than 850 youth took part in Michigan 4-H pre-college programs with an agricultural focus. These programs, which include 4-H Exploration Days and 4-H Animal and Veterinary Science Camp, among others, are designed to help youth explore potential careers or academic areas.

• 83% of youth indicated an interest and engagement in science.
• 74% of youth indicated positive attitudes and aspirations towards science.
• 91% of youth indicated they are aware of science skills learned in 4-H programming.
• 86% of youth said they could identify science skills they were learning in 4-H.

Key areas for AgBioReseach in 2016:

IMPROVING GENETIC SELECTION MAY HOLD KEY TO PEACEFUL PIG GROUPING
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.
The MSU team is compiling behavioral and genomic data from more than 1,000 pigs at the MSU Swine Teaching and Research Center. The data will be combined with information from 3,000 pigs obtained by collaborators Simon Turner and Rick D'Eath of Scotland's Rural College, experts in analyzing aggression heritability in pigs.

BEE KIND: MAKING GREENHOUSE AND NURSERY PLANTS MORE POLLINATOR-FRIENDLY
In 2015, the two largest garden center chains in the country -- Home Depot and Lowe's -- announced plans to phase out the use of a common and effective group of pesticides called neonicotinoids. The companies plan to eventually ban growers from using neonicotinoids on plants grown for sale in their stores. They also vowed to remove home garden products containing the chemicals from shelves within

two to three years.
The announcement came after several years of public pressure from advocacy groups concerned that neonicotinoids had an adverse -- and in some cases lethal -- effect on already struggling honeybee and native bee populations.
Michigan State University (MSU) AgBioResearch entomologist David Smitley is working to provide the state's greenhouse and nursery growers with tools to make their plants more pollinator- friendly and marketable without sacrificing pest management.

UNCOVERING THE ROLE OF THE PLACENTA IN PREGNANCY IMMUNE TOLERANCE

Margaret Petroff, an associate professor in the Department of Pathobiology and Diagnostic Investigation at Michigan State University (MSU), believes that decoding additional secrets to immune tolerance could lead to treatment breakthroughs for a variety of conditions.
Petroff and her team are studying a form of immune tolerance familiar to many women -- pregnancy.
The placenta acts as the biological pathway between mother and fetus and is responsible for the transport of nutrients and oxygen. But the placenta also sheds genetic material that Petroff believes may be interacting with the mother's immune system.

PREDICTING EFFECTS OF CONTAMINANTS ON MICHIGAN'S FISH POPULATIONS

A three-year project led by Michigan State University (MSU) Department of Fisheries and Wildlife associate professor Cheryl Murphy is exploring ways to protect these fish populations and the bodies of water they live in. An expert in aquatic toxicology, Murphy is directing a team
of researchers from several universities to examine the impacts of contaminants on fish populations.
Preliminary results indicate that fish exposed to increasing concentrations of methylmercury travel more slowly, their visual reactive distance varies and feeding declines. Consequently, ability to escape predators and capture food is impaired over time in the presence of contaminants. In simulations, fish subjected to a high dose of contaminants have significantly decreased survival rates.

A LONG-TERM INVESTMENT: BREEDING BETTER WHEAT FOR A STRONGER INDUSTRY

Wheat can rightly be called one of the cornerstones of American agriculture. Brought to the Western Hemisphere by colonists as early as the 15th century, wheat is now grown in nearly every state, with national production estimated at nearly 60 billion tons.
Ensuring that Michigan farmers have the best tools to meet emerging challenges and continue to produce at record-setting levels lies at the heart of the Michigan State University (MSU) wheat breeding and genetics program, led by MSU AgBioResearch plant breeder Eric Olson.
Through a technique called genomic selection, Olson's team is able to read and analyze the genotype, the collection of genetic information, of the new varieties that they develop as early as the very first cross. This helps predict in the lab how they will perform long before they make it to the field.

These stories are excerpts from our 2016 Annual Report. For more on these stories and many of the other exciting research from our scientists, please visit:
http://agbioresearch.msu.edu/publications/annual_report

Total Actual Amount of professional FTEs/SYs for this State

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	200.0	0.0	65.0	0.0
Actual	208.0	0.0	74.0	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 in order 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. Thirteen 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 a number of key activities and undertakings. ABR and MSUE continue to **develop the framework for new, industry-supported partnerships**:

• **Michigan Alliance for Animal Agriculture (M-AAA) is a new partnership between the MSU College of Agriculture and Natural Resources, ABR, MSUE and Michigan animal agriculture commodity organizations started in 2014 to advance** animal agriculture. The Michigan food and agriculture system annually contributes about $100 billion to the state's economy and provides nearly 1 million jobs. About 37 percent of the agricultural products sold are attributed to the animal agriculture sector. M-AAA focuses on advancing the state's animal agriculture economy by supporting applied research and outreach efforts that address key issues identified by the industry.

• **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 emblematic of the way ABR and MSUE work to invest in people -**

one-on-one with entrepreneurs to supply objective, evidence-based methods for starting and growing businesses. Its client base in food and agriculture businesses has grown by 18 percent. In the 2015-16 programming year, Product Center professionals conducted 4,168 counseling sessions with 645 clients. This led to:

- 62 new venture launches.
- More than $40.5 million in total capital formation, including more than $9.4 million of owner investment in Michigan businesses.
- 324 jobs created or retained.
- In addition, the **Product Center is working diligently to establish the Food Processing Innovations Lab, which will help midsized companies develop new and improved products by allowing them to establish a commercial production line to test new procedures**. It will also help prepare students for the workforce by giving them unmatched hands-on experiences in food science.

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.

Thirteen 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.

Following the establishment of the four MSUE institutes, a statewide needs assessment -- Advance Michigan -- was undertaken to seek input and direction from staff, internal and external stakeholders, and the general public on what the programmatic priorities should be within each of the institutes. Survey results were used to guide logic models for specific priorities in each institute and a statewide plan of work that will continue.

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. Results from the Michigan State University AgBioResearch & Extension Partner to Sharpen Their Focus on Community priorities Statistical Report found the top priorities from analyzing over 7,000 community residents across the state of Michigan:

Preparing today's youth for tomorrow's jobs.

Ensuring that the food supply is safe and plentiful.

Ensure a safe and plentiful water supply.

Helping communities create jobs and be great places to live.
Helping Michigan maintain a healthy and sustainable environment for work, living, and play.
Conducting research and educational programs to combat diseases and pests that threaten the health of plants, animals, and people.
Conducting research and educational programs that lead to a better environment.
Help youth develop leadership, citizenship, and other life skills.
Conducting research and educational programs to make Michigan communities healthy places to live.
Improve nutrition for all people of Michigan.
Strengthen early childhood education.
Conducting research and educational programs to build healthy and strong families.
MSUE Institute Work Teams will be integrating information from the needs assessment process in their 2018 Plans of Work.

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.

In order 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 faculty member 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.

Due to stakeholder input, ABR has focused more sharply on renewable energy and bio-based products that can help boost the Michigan economy, including fuels, chemicals, neutraceuticals and food products; the environment; land use issues; and biotechnology. Water research and food safety are also issues that are receiving increased attention and funding resources, as evidenced by the recent launches of the MetroFoodPlus Initiative and the MSU Global Water Initiative. 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 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
9270969	0	6484606	0

2. Totaled Actual dollars from Planned Programs Inputs				
	Extension		Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	8415965	0	6666372	0
Actual Matching	8415965	0	6561143	0
Actual All Other	0	0	35476110	0
Total Actual Expended	16831930	0	48703625	0

3. Amount of Above Actual Formula Dollars Expended which comes from Carryover funds from previous				
Carryover	1446057	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%		10%	
702	Requirements and Function of Nutrients and Other Food Components	0%		4%	
703	Nutrition Education and Behavior	20%		3%	
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%		5%	
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: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	106.0	0.0	11.5	0.0

Actual Paid	116.0	0.0	10.0	0.0
Actual Volunteer	78.0	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**
4422288	0	848901	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
4422288	0	835501	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	4517557	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?

An example of an activity in this area is:
Creating Healthy Communities
This group collaborated in looking at the health of communities in different states with extension programs. Discussions on making a difference in communities across the US was the main focus while discussing and updating each other on programming and new events in the world of community health. One example within this Community of Practice networking was researching work regarding trauma informed communities especially working with pre-schoolers. Another example in this CoP was RELAX: Alternatives to Anger class where MSUE staff conducted national trainings.

Another example of an activity in this area was:
Healthy Food Choices in Schools Community of Practice (CoP)
Developed Healthy Eating Dialogues subgroup that involved documenting impacts and reviewing articles to be posted.

Another example of an activity in this area was:
eXtension Adaptive Learning Grant
Researched tools for adaptive learning from two different focus areas including 1) Platforms such as D2L LeaP that use data/analytics to provide learners with a customized learning path based on certain criteria such as a pre-assessment 2) adaptive/personalized learning activities that could be used as a stand-alone learning object or as an activity within a course - an example of this would be a decision tree activity within a course (just certain activities within the course are adaptive).
Adaptive learning is an emerging online technology that lends itself to adult learners and millennials by using existing knowledge to build personalized learning - which may reduce the time for completion of a course. Adaptive learning tools create a personalized learning path for users based on data and analytics. For example, imagine a tool that presents a participant with suggested learning objects based on the results of a pre-assessment. This allows participants to learn what they need to know, as well as hopefully improve retention rates by keeping participants engaged in their learning. We will also be building some adaptive activities that could be used within a course. As an example, maybe we will create a decision tree activity that is a part of an online course. In this example, the entire course isn't adaptive but a content object within the course is personalized for the learner.

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	60940	182820	98263	294789

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

Patent Applications Submitted

Year: 2016

Actual: 2

Patents listed

MICL02354, Improvement of Meat Quality, Safety, and Nutritional Values Using Advanced Meat Processing Techniques, Serial Number 14/326,853 ; MICL02257, Hierarchical Genetic and Environmental Regulation of M. tuberculosis Complex Persistence, Serial Number 62/156,733

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	2	36	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
2016	34

Output #2

Output Measure

- Number of adult participants trained in healthy lifestyles.

Year	Actual
2016	56277

Output #3

Output Measure

- Number of youth participants trained in healthy lifestyles.

Year	Actual
2016	82534

Output #4

Output Measure

- Number of youth participants trained in life skills.

Year	Actual
2016	15084

Output #5

Output Measure

- Number of adult participants trained in family resource management.

Year	Actual
2016	4663

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
2016	616

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

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
2016	9

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
While about 175 different types of foods have been documented to trigger an allergic reaction in sensitized subjects, 90% of food allergies are due to 8 major food types: Chicken egg, cow's milk, soybean, wheat, peanut, tree nuts, fish and shellfish. Notably, as reviewed recently, improved methods for predicting allergenicity of food proteins are critically needed. A promising approach is to test if a dietary protein might induce allergic reactions in a validated food allergy mouse model. However, a validated mouse model of food allergy is not available at present to evaluate allergenicity of novel foods.

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
Both the prevalence and severity of food-induced allergic reactions are growing at an alarming rate for reasons that are incompletely understood. Wheat is identified as a major red-flag allergenic food in many countries including the USA. Although animal models are very useful to study wheat allergy, a mouse model of hypersensitivity to salt-soluble wheat protein (SSWP)--more common type of wheat allergens--is unavailable. Here we tested the hypothesis that SSWP from
durum (Carpio) wheat will elicit allergic response in BALB/c mice.we report a novel mouse model of immediate hypersensitivity to SSWP

for the first time.

Despite vaccination, influenza and its secondary pneumonias cause a reported 200,000 hospitalizations and 36,000 deaths annually in the United States and is the fifth leading cause of death in persons over 65. In addition, the inefficacy of vaccination, particularly in vulnerable populations such as the elderly, coupled with the threat of newly emergent strains of influenza, such as highly virulent (HV) H5N1, highlights the critical need to better understand the primary immune response to influenza. Thus, the long term goals of our research are to better understand age-related changes in primary responses to influenza infection and identify therapeutic strategies to maintain or enhance resistance to this virus. We have begun experiments to determine if the onset of CR at various ages, ranging from adult, middle-aged and aged
mice impairs NK cell function and phenotye. We have developed feeding protocols in which we can gradually induce 40% CR in adult and aged mice. We are currently developing these same feeding protocols in middle-aged mice. We have shown that even short-term CR of adult mice deleteriously impacts NK cell phenotypes and cytokine production.

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
2016	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Nitrogen availability is critical for crop production yet excess nitrogen poses a significant environmental threat. The threat to groundwater and surface waters is well recognized and

understood; the threat to air quality is more poorly recognized but no less real. Nitrogen trace gases can significantly affect regional / global climate over long time scales, as can other trace gases such as methane. Agricultural landscapes may play a critical role in global balances of these greenhouse gases, and the inclusion of perennial biofuel crops in the landscape may represent a mitigation option.

What has been done
Research to: understand greenhouse gas and carbon sequestration in regards to agriculture landscapes; evaluate pregnancy outcomes related to food and environmental factors; Understand the role of innate lymphoid cells in air pollutant induced onset of non-atopic asthma and rhinitis.

Results
This research contributed to our understanding of the ecological basis for greenhouse gas fluxes to the atmosphere. The role of agriculture in these fluxes - whether as a source or sink - is important to know in order to develop effective greenhouse gas mitigation strategies at a national level. The development of carbon credit trading, expanded to include other greenhouse gases, depends on a sound scientific understanding of these issues. Long-term research aids the discovery and
methodologies for creating credits and is an important part of this national endeavor.

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
2016	9

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Despite being called "invisible" children of a parent with a mental illness are numerous and at significant developmental risk. One of five Americans has a serious mental illness and 25 to 40 percent of them are parents. Children with a parent with a mental illness have a higher risk for acquiring a mental illness. The children know little about mental illness and recovery despite asserting that their lives are affected by adjusting from one moment or one day at a time to the level of parental symptoms. Many of the children report believing that they are at fault for the parents' illness. They may endure times of separation from their parent with a mental illness. They are more likely to enter kinship care or foster care.

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

Michigan State University Extension staff were trained to serve as nutrition and smarter lunchroom coaches for schools. Schools were recruited and participated in making smarter lunchroom changes. Before and after data were collected. 2 iPad apps to collect plate waste data in school cafeterias are under development, along with a nutrition education curriculum to train 5th through 8th grade students to use the apps

Michigan's U.P. is an economically depressed region in the Great Lakes Basin with inadequate access to nutrient dense foods. There is increasing consumer demand for local nutrient dense food and expressed interest by producers on technologies and innovations relevant to its production. Integrating a nutrient dense food production Incubator Farm into the Upper Peninsula Research and Extension Center has provided a focal point for research, education and extension efforts to improve the sustainability and resiliency of agriculture and food systems in Michigan's U.P. The development of formal and non-formal research-based educational programs targeting beginning farmers and avocational growers is resulting in anincrease in people in the U.P. growing nutrient dense food. An increase in the number of farmers producing nutrient dense food destined for the local economy adds resilience to the food security of the region. Through the utilization of conservation agricultural practices with an emphasis on soil health, the environmental quality of the region can be improved - especially the U.P.'s marginal soils. The anticipated resulting societal benefit is an increase in the amount of nutrient dense food within the U.P. economy, with a simultaneous improvement in soil health and in the economic sustainability of the region.

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
2016	49524

3c. Qualitative Outcome or Impact Statement

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. To be most effective, chronic disease prevention requires a multi-sector approach across the lifespan, which includes health promotion, early detection, and appropriate management of chronic disease (The Power of Prevention 2009).

What has been done
In response to this need, one example is where MSUE developed and implemented 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 2016, 453 participants from 11 counties participated in the Dining with Diabetes program taught by 6 instructors. Evaluation results found:

100% are confident that when it comes to diabetes and health, they know what they can do to make a positive difference for themselves or for the person they care for with diabetes.
87% are confident they can keep their diabetes under control, or help the person they care for keep their diabetes under control.
85% disagree that diabetes is not serious even if someone feels fine.
62% are feeling overwhelmed by the demands of living with diabetes or caring for someone living with diabetes.

Participants adopt healthy food practices as a result of the Dining with Diabetes classes.

58% increased their 20 minutes or more exercise performed weekly

51% reported eating a variety of fruits and vegetables more often weekly

44% considered portion sizes when making meal choices

74% reviewed the food label before eating more often during the week

57% checked their feet more often during the week

44% decreased the number of fried foods in their weekly diet

53% increased their weekly frequency of five or more servings of fruits and vegetables in a day

49% reported having three servings of dairy products in a day more often in a week

28% decreased weekly consumption of sugary beverages

38% ate baked fish prepared with little or no added fat more often weekly

As a result of participating in the Dining with Diabetes program:

81% fit exercise into their daily routine
44% exercise continuously for at least 30 minutes at least three times a week
75% participate in physical activity such as walking on a daily basis
86% cook more at home
98% eat smaller proportions
80% are using recipes provided by the program

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
2016	80647

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example, consists of school gardens, youth gardens, and farm-to-school initiatives become increasingly popular across Michigan, youth need more information and hands-on opportunities to learn proper food preservation techniques.

What has been done
MSU Extension adopted the youth food preservation curriculum "Put It Up," recently developed and published 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 2016 over 340 youth across 6 counties received hands-on lessons in one of four areas- jam-making, water bath canning, pickling, or freezing. 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.

Difference:

The adoption of a youth-specific food preservation curriculum provides Michigan youth with age-appropriate lessons and hands-on exposure to one of the oldest sciences used by humans. This opportunity enhances life skills, teaches about where food comes from, and instills a sense of self-sufficiency in youth.

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
2016	4998

3c. Qualitative Outcome or Impact Statement

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. Conditions such as heart disease, cancer, lung disease, skeletal fractures, and liver disease showed a relationship to adverse childhood experiences. The findings suggest that the impact of these adverse childhood experiences on adult health status is strong and cumulative. (Fellitti 1998) Factors that mitigate the effects of ACEs include social-emotional buffering, parental resilience, early detection and early intervention. 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
MSU Extension is committed to helping people improve their lives through research and evidence based educational programs. In an effort to promote prevention of child abuse and neglect and to promote protective factors in families, educators from the Health and Nutrition Institute/Social Emotional Health and Children and Youth Institute?s Early Childhood Development team worked collaboratively to offer two programs in 9 counties across Michigan; Nurturing Parenting and Building Early Emotional Skills (BEES).

Results
MSU Extension uses the Protective Factors Survey to evaluate results of the Nurturing Parenting Program and the Building Early Emotional Skills CTF Grant Program. The instrument measures protective factors in five areas: 1) family functioning and resiliency, 2) social and emotional support, 3) concrete support, 4) nurturing and attachment, and 5) knowledge of parenting/child development. The Protective Factors Survey is administered pre and post series.

Results (n=174 Pre and Post Completed Protective Factors)

62% 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.
42% Improvement in Social and Emotional Support ? Perceived informal support (from family, friends and neighbors) that helps provide for emotional needs.
41% 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.
34% 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 an understanding and utilizing effective child management techniques and having age appropriate expectations for children?s abilities.

40% Improvement on PFS Item 12: I know what to do as a parent.
36% Improvement on PFS Item 13: I know how knowledge on how to help my child learn.
28% Improvement on PFS Item 14: I realize my child does not misbehave just to upset me.
27% Improvement on PFS Item 15: I praise my child when they behave.
20% Improvement on PFS Item 16: When I discipline my child, I don?t lose control.

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
2016	14589

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Often times youth are unaware of possible careers and the skills and education needed to pursue these careers.

What has been done
One example is MSUE conducted Career Exploration at the Muskegon Juvenile Transition Center that was a series of four sessions. Students took a career assessment, participated in activities for the levels of education and salaries, the skilled trades and salaries in the skilled trades.

Results
There were a total of 36 students who participated in the sessions. Students were evaluated at the end of the sessions. The evaluation results were:

29.4% increase in the students who agreed that they were aware of the various careers that are available in fields that have connections to their interests, skills, and experiences.
29.4% increase in the students who agreed that they have identified potential careers in their field of interest.
41.2% increase in the students who agreed that they knew the specific education, skills, and characteristics needed to be successful in a career they have explored.
31.3% increase in the students who agreed that they understood the different requirements of postsecondary educational degrees and certifications in careers they have explored.
31.2% increase in the students who agreed that they were more aware of the advantages and disadvantages of being an entrepreneur vs. being an employee.
35.3% increase in the students who agreed that they have identified the steps necessary for them to reach their career goals.

4. Associated Knowledge Areas

KA Code	Knowledge Area
802	Human Development and Family Well-Being
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
2016	3567

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Promotion of supportive relationship and rich learning environments for young children creates a strong foundation for academic achievement and success in adulthood. High quality early childhood development programs, including parent education programs and support programs for families with infants and toddlers have been proven to be cost-effective ways to reduce the harmful effects of economic hardship on child development.

What has been done
One example in this area is: MSUE conducted a eight-week parent education series that provided 1) Education for parents and caregivers on the basic concepts of early childhood development 2) Education on ways to keep children socially, emotionally, and physically safe and 3) Techniques that help children learn, and promote school readiness.

Results
Evaluation results of the workshop found:

88% improved their skills to promote healthy communication

91% learned new skills needed for healthy relationships

95% gained awareness of how to keep relationships safe (physically, emotionally, and socially)

92% increased knowledge in basic concepts of healthy relationships

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
2016	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The need to develop economically and environmentally sound approaches to address environmental and natural resources challenges is increasingly important. Policies, practices and science-based knowledge must constantly evolve to promote stewardship and sustainability in light of new opportunities for increased productivity, resource-saving technologies and threats to biodiversity. Research is needed to ensure that practices and policies have a strong, science based foundation.

Waste treatment is one of the most pressing challenges to the sustainability of agroindustries. Agroindustrial wastes, such as those generated from bioenergy or food processing, can contain high concentrations of carbon or nutrients that can adversely impact ecosystems if discharged to surface waters or can cause metal and nitrate contamination of groundwaters if applied to fields. Even land application of treated wastes, such as wastewater treatment plant biosolids, can introduce pollutants, such as pharmaceuticals or personal care products, into agricultural ecosystems and the human food chain.

What has been done

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

Results

Tropical forests are changing in species composition, with a possible shift towards low wood density species, lianas, and drought-deciduous species, which may be a consequence of climate change. Predicting future species composition of the canopy remains a challenge, as it depends on the survival and growth of seedlings (Kobe 1996; Pacala et al. 1996), and their responses to climate change. The study evaluates climate (rainfall and temperature) effects on tropical tree seedling production (by mature trees), and seedling growth and survival, which will determine future composition of trees in the canopy. Developing process-based models to predict future forest composition in wet tropical forests is not merely an academic exercise but is crucial to global carbon storage and climate as well as the conservation of biological diversity. Tropical forests contain approximately 25% of global terrestrial carbon stocks. The rate of mature tree mortality in tropical forests is generally increasing and the carbon that those dying trees contain will transfer to the atmosphere as the wood decomposes. The characteristics of the tree species that replace current and dying trees for future generations will strongly influence the capacity of tropical forests to store carbon and sequester it from the atmosphere.
We have monitored the growth and survival of woody seedlings on a six week interval and have continued measurements of light availability. We continue to monitor tree flower and fruit production. We have developed models of annual tree reproductive output. With the methods worked out, we now are in a position to examine effects of climatic variation on tree reproductive output. We also have compiled weather data for the field sites, which enables examining tree and seedling responses to climatic variation.

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
2016	4197

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
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. Home values have gone up, but not in every county and there is a lack of affordable housing due to increase in demand for rentals. Medical insurance premiums have continued to increase while energy costs have continued to stay low.

What has been done
MSU Extension has an important role to play in addressing issues of financial health of individuals and families through community-based educational programs. The overarching goal of these efforts is for Michigan consumers to 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. One example is Dollar Works and Money Smart. Money management courses offer different topics over several weeks. These courses utilize two curriculums: Dollar Works and Money Smart. Dollar Works topics include setting financial goals, creating a spending plan, using credit wisely, pumping-up savings, keeping spending records, and protecting against identity theft. Money Smart topics include making money decisions, credit use, paying off debt, spending plans, keeping records, and money issues.

Results
Evaluation results of one of the programs found: During 2016, MSU Extension reached nearly 965 adults in over 132 programs on managing personal and household finances. Program delivery ranged from 90 minutes to 360 minutes per session, with the average session lasting 120 minutes. Number of sessions ranged 1 to 5. Average age of participants was 36 years and 62% were women. Annual income was less than $18,000 for 57%% of the participants. Participants employment status was 42% unemployed and 41% employed part- or full-time. Most (48%) rented at current residence and 24% lived with family. Six percent had experienced home foreclosure in the past few years. Half (48%) expect to purchase a home in the next 3 years. 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=376):
- 85% write out a spending plan
- 85% make choices today that will make retirement a reality
- 84% save money regularly

- 83% write SMART financial goals
- 83% keep track of spending and income
- 81% obtain a housing payment that fits within a budget
- 80% pay bills on time
- 79% review all credit card bills and financial statements
- 79% obtain and review credit report annually
- 77% pay down debt or pay off new credit card charges each month

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
2016	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Processed meats have received negative publicity due to their typically high fat and high sodium contents, which have been linked to adverse effects on human health. In addition, consumption of Listeria contaminated process meats was linked to a massive multistate outbreak including many fatalities, miscarriages or stillbirths. In case of poultry products, incidence of poultryborne salmonellosis and campylobacteriosis has remained relatively unchanged despite of various intervention strategies at farms and processing plants.

What has been done
Research to: identify more effective, efficient and greener, plant-based processes to produce pharmaceuticals; 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

As the world population grows, our need for food and fuel increases. Yet the amount of arable land is limited, and often there is now a competition between food and fuel crops. In addition, changes in the global climate may impact future yields. Drought, heat and cold are abiotic stressors most commonly affecting crop yield. Pathogens infect and destroy nutritionally advanced crops. To continue to be able to provide sufficient food and fuel for an increasing world population, we need plants that show accelerated growth, have a higher grain yield, or are more resistant to stress. According to the World Resources Institute, worldwide, 1.2 billion people are facing water scarcity and 36 countries are experiencing extreme water stress. Hence, even slight improvements in water use efficiency and drought tolerance will not only enhance yield and survival but also reduce water usage, thus ensuring water security. Our goal is to understand how we can prevent crop loss due to water stress. To accomplish this it is essential to understand the signals responsible for changes in plant development and the resulting adaptation and resistance to drought.

Unlike animals, plants cannot escape adverse conditions. To allow for an efficient exchange of information (signals), plants have two long-distance transport systems: the xylem for water and mineral distribution from the roots throughout the plant, and the phloem. The view of phloem function has evolved from that of simple assimilate transport system to a trafficking system for stress signals and developmental regulators in the form of small molecules, peptides/proteins, nucleic acids, and more recently, lipids. Thus, the study of signaling compounds within the phloem is essential for our understanding of the transmission of environmental cues throughout the plant. In the previous funding period we have identified several phloem-localized putative lipid-binding proteins from Arabidopsis that could participate in the transmittal of environmental signals.

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
2016	774

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
25% of Michigan youth in grades 9-12 reported they had been bullied on school property and 19% reported they had been bullied electronically. Both of these statistics are above the national average.

What has been done
One example is where MSUE conducted a training on bullying that had 774 young people and adults take part in educational programs to address issues of bullying and harassment while promoting healthy social and emotional development.

Results
Evaluation results found: 66% reported using new ways to take care of themselves; 56% reported providing support to peers who were bullied; and 73% reported noticing positive changes in their setting

What difference did it make - public value?

Reducing the risk for physical injury and emotional distress including anxiety, depression and lowered academic performance, as well as economic costs associated with adolescent aggression and violence.

4. Associated Knowledge Areas

KA Code	Knowledge Area
724	Healthy Lifestyle
802	Human Development and Family Well-Being
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 2015-16 fiscal year, ABR and MSUE were able to 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 600 in 2015. Project GREEEN funds supported operational upgrades including strategic network and system modernization, as well as routine weather network maintenance. Sixteen Enviro-weather stations were upgraded with new loggers and sensors in 2015-16. Two new stations were added to the Enviro-weather network: Deerfield in September 2015 and Elbridge/Hart in May 2016.

Project GREEEN funds are used by the Land Management Office to help keep MSU AgBioResearch centers operating at full capacity. Funds are often used for new equipment and skilled labor positions. Many research centers were able to provide maintenance and repair services to infrastructure in 2015-16 through Project GREEEN, as well as funding for field trials, pest management and more. Numerous research center projects also benefited from Project GREEEN dollars, including:

- Monitoring for invasive grape pests.
- Sweet cherry bacterial canker research.
- Spotted wing drosophila monitoring in fruit crops.
- Trevor Nichols Research Center field lab renovations.
- Clarksville Research Center asphalt replacement and repair.

Together, MSUE and ABR continue to serve as the primary research and development arm for the agriculture and food industries in Michigan, valued at more than $100 billion annually.

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 evaluation.

Nutrition and Physical Activity

Situation

There are a large number of people living at or below the poverty level; high levels of obesity among adults; and low levels of adults consuming the adequate amount of fruits and vegetables in Michigan. These are factors that affect the quality of life for adults and their families, and increase their likelihood of chronic diseases.

- In Michigan, 16.9% were considered below the poverty level in 2014 (US Census Bureau 2016).
- Based on USDA data, 1,506,532 people (15.2%) are receiving Supplemental Nutrition Assistance Program benefits- Bridge Card in Michigan (USDA Food and Nutrition Service 2016).
- On average for 2012-2014, 14.7% of households in Michigan were considered food insecure, and 6.3% of households in Michigan were considered to have very low food security (USDA ERS 2016).
- The median income of SNAP-recipient households is $17,460 (USDA FNS 2015)
- Over 47% of all SNAP participants are in working families (USDA Food and Nutrition Service 2015), and 42.7% of those who receive SNAP Benefits in Michigan are adults living with children (USDA Food and Nutrition Service 2015).
- Michigan has the 17th highest prevalence of obesity in the United States (Trust for America's Health 2015). Three out of every ten adults (30.7%) in Michigan are obese, while approximately 35% of adults are overweight (Michigan Behavioral Risk Factor Survey 2014). 13.0% of Michigan youth are considered obese (Michigan YRBS 2013).

Response

Nutrition and physical activity education are a means to prevent obesity among adults and to prevent and decrease chronic diseases. Michigan State University (MSU) Extension delivers high-quality and affordable education to serve the needs of children, youth, families and communities in urban, rural and suburban areas.
MSU Extension programming promotes healthy life-styles and educates Michigan residents, allowing each individual to acquire the skills to take control of his or her personal health. The Nutrition & Physical Activity Workgroup (NPA) of the Health and Nutrition Institute of MSU Extension works to improve the knowledge, skills, attitudes and behavior of individuals regarding nutrition and physical activity. Through promotion, planning and delivery, MSU Extension staff members provide education to diverse audiences at the local, county and state level.

Results

One example comes from the results of the evaluation of SNAP-Ed programming at the Academy of Warren in Macomb County, Michigan, from October 1, 2015 to June 15, 2016. In total, 517 students participated and 468 (91%) completed the program. Evaluation results presented below are for students who completed both the pre- and post-class evaluation questionnaires, which included 190 students (36.7%) in 3rd to 5th grades and 169 students (32.7%) in 6th to 8th grades. Teachers completed observation forms to assess changes in the 158 participating students (30.6%) in kindergarten to 2nd grades.

• 86% improved their knowledge or ability to choose foods according to Federal Dietary Recommendations.

• 58% improved their physical activity practices or knowledge.

• 43% use safe food handling practices more often or gained knowledge.

• 48% improved their knowledge or ability to prepare simple, nutritious, affordable food.

Another example,

Michigan FoodCorps Program 2016

Issue (who cares and why)?

FoodCorps is a nationwide team of AmeriCorps leaders who connect kids to healthy food in school and help them grow up healthy. In Michigan, the FoodCorps program is administered by the Michigan State University Extension Community Food Systems team - a statewide network of Extension Educators who's Farm to Institution work is closely aligned with FoodCorps goals for healthy food consumption in schools and communities by changing institutional food environments and increasing the amount of local food served. FoodCorps service members serve across the state to provide food-focused learning in high-needs classrooms. They add capacity to community-based schools and organizations (called FoodCorps Service Sites) led by Site Supervisors who have already established successful food programming and extensive partnerships in communities to positively influence school food environments. They do this through hands-on learning in school gardens, cooking and tasting lessons, and supporting the purchase and service of nourishing, locally produced foods in the cafeteria; promoting a schoolwide culture of health. This FoodCorps strategy is based on the "Farm to School' approach that has been endorsed by The Centers for Disease Control and Prevention, the United States Department of Agriculture and the White House Task Force on Childhood Obesity. And in October, we celebrate National Farm to School month!

What has been done?

FoodCorps has been in Michigan since the program launched in 2010, and this school year (2017), for the first time nationwide, we have a FoodCorps member who was inspired to do this work by the FoodCorps service member who taught her in Traverse City, MI five years ago. This year, in response to the lead crisis in Flint, since good nutrition is one of the few scientifically supported ways to reduce lead uptake among exposed children, the national program scaled up our team there, growing from two to six locally-recruited service members. By graduating a service site out of the program at the end of the school year in July, we were able to bring a new service site at Muskegon Public Schools on board in September. From urban Flint and Detroit to rural northern MI, FoodCorps Michigan stitches together diverse programs across the state that all have one thing in common: making children's health a priority.

Ten FoodCorps service members were located in Michigan at seven service site locations in the 2016 program year (9/1/15 - 7/31/16):

• Crim Fitness Foundation in Flint
• Detroit Black Community Food Security Network in Detroit
• Detroit Public Schools
• Groundwork Center for Resilient Communities in Traverse City
• Michigan State University Extension - Chippewa County in Sault Ste. Marie
• Wayne State University Center for School Health in Detroit

Michigan State University Extension-Grand Traverse in Traverse City
Results/Impact?
FoodCorps Michigan service members in the 2016 School Year contributed the following impacts:

- 6,344 children served;
- 1,578 student activities conducted;
- 9,422 pounds of local food harvested; 14 gardens built
- 134 cafeteria tasting events; 13 new foods introduced
- 349 community volunteers performed 1,867 volunteer hours
- 565 Teachers and staff trained to build capacity/technical assistance

Another example,
Water Safety
Issue (who cares and why)? Great Lakes Dangerous Currents take many lives each year of those swimming in the Great Lakes.
What has been done? Michigan Sea Grant working with the Great Lakes Sea Grant Network secured a Coastal Storms grant that allowed the distribution of water safety rescue equipment to high risk areas for dangerous currents around the Great Lakes.
Results/Impact? Two lives have been saved because of the use of this water safety rescue equipment.
What difference did it make - public value? Rescue equipment made available in high risk dangerous current zones along the Great Lakes will assist with rescue efforts and save lives.

Another example,
Matter of Balance
Relevance or Issue
Many older adults experience a fear of falling. People who develop this fear often limit their activities, which can result in physical weakness, making the risk of falling even greater. Matter of Balance is a program designed to reduce the fear of falling and increase activity levels among older adults. Matter of Balance includes eight two-hour sessions for a small group led by two trained facilitators. During the class, participants learn to view falls as controllable, set goals for increasing activity, make changes to reduce fall risks at home, and exercise to increase strength and balance.
Response
During 2016, 203 adults participated in the Matter of Balance program. Participants were from 11 counties: Allegan, Barry, Crawford, Grand Traverse, Iron, Isabella, Kalamazoo, Kent, Marquette, Ontonagon, and Otsego.
Six staff instructing and evaluating the Matter of Balance program: Laura Anderson, Erin Carter, Linda Cronk, Christi Demitz, Diana Hassan, and Gretchen Stelter.
A profile of audience for Matter of Balance programs includes:

- 78% women
- Average age: 75 years, range from 52 to 96 years
- 22% high school graduates, 22% reported some college and 45% college graduate
- 7% have applied for and received SNAP benefits in last 12 months
- 91% White/Caucasian, 6% Black or African American, 3% Hispanic or Latino ethnicity

Results
Results from the program evaluation (n=76) show how participants gained knowledge and skills on outcomes improving health, safety and well-being. Most (97%) participants would recommend the Matter of Balance program to friends and relatives.

As a result of the program:

- 94% learned ways to reduce falls;
- 89% learned strategies to address concerns about falling so they could continue regular social activities;
- 75% will continue to exercise to increase their physical strength;
- 74% are more confident they can find ways to get up if they fall;
- 58% plan to change their environment to lower their risk of a fall(s).

Another example,

Animal Well-Being During Fairs & Expos

Audience

Farmers, Agriculture Allied Industry representatives and community members (Branch county and surrounding areas) that have an interest in Agriculture and current topics surrounding the Agricultural industry. A 90 minute session was conducted targeting youth regarding animal care and well-being with special consideration for fairs and expos.

Objectives

This presentation was designed to:

- Introduce youth to the concepts of animal well-being.
- Discuss how these topics are important for every day care of their livestock.
- Explore special considerations for fairs and expos, such as heat stress, food water availability, and biosecurity.

Description

This one session of many offered during the event. There was 90 minutes of contact time with participants, most of which were youth, but adults were present. Evaluation data reflects only that of youth participants.

Impacts

As a result of this presentation:

- 83% of youth indicated an interest and engagement in science.
- 74% of youth indicated positive attitudes and aspirations towards science.
- 91% of youth indicated they are aware of science skills learned in 4-H programming.
- 86% of youth said they could identify science skills they were learning in 4-H.

Another example,

Conservation Education

MSU Extension and 4-H of the Central U.P. and Southeast Michigan seek to connect youth from both urban and rural areas of our state to the natural world through exposure to conservation education, outdoor recreation, and team building activities.It will also provide the opportunity for youth to meet and interact with people outside of their usual social and cultural experiences. By disconnecting from technology and reconnecting with nature and each other, participants will discover truths about themselves and their world and create new lifelong habits including enjoyment and stewardship of natural and cultural resources . .

Goals

- Bring youth from two very different areas of the state together to explore nature, learn about themselves and one another through various cultural activities that encourage self-exploration and cross-cultural sharing.
- Provide opportunities for youth to bond as teams or cabins by participating in low ropes course activities and other team building exercises

- Provide opportunities for youth to explore multiple careers related to natural resources and environmental issues and encourage goals setting and planning for their futures
- Provide opportunities for youth to bond as teams or cabins by participating in low ropes course activities and other team building exercises
- Expose youth to a natural environment and teach them the importance of land management and responsible stewardship
- Strengthen partnerships between MSU Extension and various agencies to encourage future collaboration on project

Results/Impact?

Leadership/Civic Engagement- Dealing with Conflict

In a retrospective pre/post evaluation, 58% of participants indicated a gain in their ability to use communication skills to address conflict effectively.

In a retrospective pre/post evaluation, 29 %of participants indicated a gain in their ability to resolve differences with others in positive ways as a result of attending Bigley Camp.

In a retrospective pre/post evaluation, 36 % of participants indicated a gain in their ability to work things out when others don't agree with them as a result of attending Bigley Camp.

In a retrospective pre/post evaluation, 39 % of participants indicated a gain in their ability to consider the ideas of others even if they are different than their own ideas as a result of attending Bigley Camp.

Career Exploration

In a retrospective pre/post evaluation, 48% of participants indicated a gain in their identification of potential careers as a result of attending Bigley Camp.

In a retrospective pre/post evaluation, 39% of participants indicated a gain in their awareness of the various careers that are available in fields that have connections to their interests, skills, and experiences as a result of attending Bigley Camp.

Leadership/Civic Engagement- Communication

In a retrospective pre/post evaluation, 48% of participants indicated a gain in their confidence to speak in front of groups as a result of attending Bigley Camp.

In a retrospective pre/post evaluation, 42% of participants indicated a gain in their effort to repeat what someone has said back to them to make sure they understand as a result of attending Bigley Camp.

In a retrospective pre/post evaluation, 39% of participants indicated a gain in their understanding of the importance of non-verbal communication.

In a retrospective pre/post evaluation, 45% of participants indicated a gain in their confidence to share their thoughts and feelings with others.

Key Items of Evaluation

MSU scientist looking at fatty acids to stop stunting, poor cognitive development

An expert on human nutrition at Michigan State University (MSU), Jenifer Fenton knows the harsh consequences of malnutrition. Some of her ongoing work is in Africa, a continent where 40 percent of children are stunted and nearly 20 percent are underweight, and more than half of the deaths are from nutrition-related illnesses. The effects of poor access to food, especially nutrient-rich foods, are devastatingly apparent throughout this expansive continent.

Fenton, an associate professor in the Department of Food Science and Human Nutrition, said that there is an abundance of research in developing countries examining the impacts of iron deficiency and carbohydrates, but not much has been done on essential fatty acids. These are necessary fats that are not naturally produced in the body.

"We did some background work and found that very few people are studying whether children in developing countries are deficient in essential fatty acids," she said. "Those are fatty acids that are not synthesized by the body. We can't make linoleic acid, an omega-6 fatty acid, and alpha-linolenic acid an omega-3 fatty acid. Those have to be consumed."
Article continued at:
http://agbioresearch.msu.edu/news/msu_scientist_looking_at_fatty_acids_to_stop_stunting_poor_cognitive_develo

MSUE Institute Work Team Adult Outputs for this area:

Institute for Agriculture and Agribusiness

10,659	AABI-03-Consumer Horticulture
16,280	Public Event, Breakfast on the Farm, Ag Literacy, Consumer Ed, etc.

Institute for Children and Youth*

5,150	Academic Success
2,714	Capacity Building
552	Career Education/Work Force Preparation
1,390	Leadership & Civic Engagement
4,032	Michigan 4-H Youth Development

Institute for Greening Michigan

6,594	GM-1. Community Food Systems
3,547	GM-2. Natural Resources Stewardship
2,505	GM-3. Government and Public Policy
423	GM-4. Entrepreneurship
5,781	GM-5. Michigan Sea Grant
4,663	GM-6-Finance/Homeownership Education
509	GM-7-Leadership and Community Engagement (LCE)
243	GM-8-Tourism

Institute for Health and Nutrition

3,051	HN-1. Disease Prevention and Management
6,456	HN-2. Food Safety
48,096	HN-3. Nutrition and Physical Activity
5,130	HN-4. Promoting social and emotional well-being

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%		5%	
102	Soil, Plant, Water, Nutrient Relationships	35%		12%	
111	Conservation and Efficient Use of Water	10%		15%	
112	Watershed Protection and Management	5%		10%	
123	Management and Sustainability of Forest Resources	5%		6%	
131	Alternative Uses of Land	10%		6%	
132	Weather and Climate	0%		10%	
133	Pollution Prevention and Mitigation	5%		10%	
134	Outdoor Recreation	0%		1%	
135	Aquatic and Terrestrial Wildlife	0%		10%	
216	Integrated Pest Management Systems	20%		15%	
806	Youth Development	10%		0%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	15.6	0.0	11.5	0.0
Actual Paid	16.0	0.0	14.0	0.0
Actual Volunteer	78.0	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**
737382	0	1173481	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
737382	0	1154958	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	6244858	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?

One example in this area (note this example could also fall under Plants) was,
MSUE hosted for eXtension two courses:

- Greenhouse and Horticultural Lighting
- Biological Control for Greenhouse Growers Course
-

Some of the Ask an Expert questions in this area focused on:

- failing septic drainfields
- controlling cattails on shorelines
- silt on lakes
- safe weed control on lakes
- how to start a wildflower project
- use of glyphosates in treating lake weeds
- pond landscaping
- wetland plant ID
- seaweed in lakes
- regenerating water softener

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	19987	59961	85231	255693

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

Patent Applications Submitted

Year:	2016
Actual:	1

Patents listed
MICL02306, Development and Applicaton of Pheromones for Control of Aquatic Invasive Species, Serial Number 61/828,001

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total

Actual	2	38	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

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

Year	Actual
2016	46

Output #2

Output Measure

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

Year	Actual
2016	10659

Output #3

Output Measure

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

Year	Actual
2016	9328

Output #4

Output Measure

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

Year	Actual
2016	85231

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.

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
2016	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
Antibiotic resistance is a worldwide health risk but the influence of animal agriculture to the genetic context and enrichment of individual antibiotic resistance alleles remains unclear. Using quantitative PCR followed by amplicon sequencing, we quantified and sequenced 44 genes related to antibiotic resistance, mobile genetic elements and bacterial phylogeny in microbiomes from U.S. laboratory swine and swine farms from three Chinese regions. We identified two highly abundant resistance clusters: groups of resistance and mobile genetic element alleles that co-occur and were dramatically enriched and independent of phylogenetic composition suggesting that they are likely present in many bacterial taxa. The resistance clusters encode resistance genes for antibiotics independent of their use, hence selection for these clusters is likely due to only a subset of the broad range of chemicals to which the clusters confer resistance. The next question is how global are
these resistance and mobile gene clusters. To more comprehensively assess environmental antimicrobial resistance, we have collaborated with the Univ of Hong Kong to produce a merged, cleaned and structured database for efficient searching of shotgun metagenomic data for antibiotic resistance genes. For biodegradation studies, we conducted a transcriptomic study of

Sphingomonas wittichii strain RW1 using RNA-Seq to outline transcriptional responses to dioxin, dibenzofuran, and
smectite clay. The ability to grow on dioxin is rare compared to growth on the chemically similar dibenzofuran. Stress response genes were up-regulated in response were more strongly upregulated with dioxin suggesting a higher toxicity of dioxin. Dioxin and dibenzofuran induced the catechol ortho- and the salicylate/gentisate pathways, respectively. Clay caused down-regulation of genes for cell motility and chemotaxis, particularly those involved in the synthesis, assembly and functioning of flagella. Clay is a major component of soil microbes' microenvironment influencing local chemistry and may serve as a geosorbent for toxic pollutants.

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
2016	8561

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One need in this area is helping professionals and general public with understanding the relationship between agriculture and natural resources and strategies to address the various issues.

What has been done
To address this need MSUE conducted the Highland Ag and Natural Resources Conference In partnership with the Natural Resource Conservation Service and the Missaukee, Osceola and Wexford County Conservation Districts, held the first Highland Ag and Natural Resources Conference. The goal of the conference was to provide a variety of one hour, concurrent educational sessions with topics including soil health, novel crops, getting started with livestock,

timber sales, youth development, invasive plants and much more. The conference was held at the Wexford-Missaukee Career Tech Center in Cadillac.

Results
Ninety-two people registered for the event and 14 sponsors and vendors also attended. Registrants hailed from the following counties: Allegan (2), Barry (1), Benzie (4), Cheboygan (1), Clinton (1), Grand Traverse (4), Ingham (3), Isabella (1), Kalkaska (3), Kent(2), Lake (3), Manistee (3), Mecosta (3), Missaukee (17), Montcalm (1), Osceola (25), Shiawassee (1), and Wexford (12).

Thirty-three attendees responded to the post-program evaluation. Twelve were female, 16 were male and five failed to report. One respondent was multiracial, 5 failed to respond and 27 self-reported as Caucasian.

Impact

Respondents (n=33) reported an acreage impact of 6,383 acres. Twenty-six respondents identified themselves as growers or future growers, 2 as students, 2 as forest landowners, 2 as non-MSU educators, and 1 as a Master Gardener volunteer.

Based on their participation in the meeting, respondents (n=33) indicated the following:

66% will utilize MSU resources (e.g. MSUE News, Enviroweather, webpages, Extension staff)
50% will utilize Conservation District resources (MAEAP, forest consultants, tree sale, invasives)
31.25% will utilize USDA Natural Resource Conservation Service resources (conservation planning and financial assistance)

The following percentage of respondents (n=33) indicated they expanded their knowledge of the following topics based on information presented at the conference:

69% Cover cropping selection, seeding or establishment

53% Practices that improve nutrient management decisions (e.g. soil or tissue testing)

56% Practices to improve soil health (e.g. cover cropping, health evaluation, amendments)

9% High yield wheat production practices

13% Potential vegetable crops for northern Michigan

16% Growing malting barley and hops

9% Consumer perceptions of the health aspects of beef and milk products

19% Marketing options for farm products

13% What it takes to get started with livestock

3% Dairy manure handling and utilization

19% Hay and pasture production practices

16% Habitat that supports pollinators

19% Invasive species threatening farm land

6% Information related to professional forestry assistance

9% Resources related to wildlife cooperative

16% Educational opportunities in ag and natural resources

Respondents (n=33) also reported that they would consider implementing or expanding use of the following practices based on information presented at the conference:

69% Cover cropping

59% Soil nutrient and health testing

9% High yield wheat production practices

28% Farm diversification through vegetable, hop, malting barley or livestock production

22% Utilizing new marketing strategies

13% Managing and monitoring for invasive species

9% Use of a professional forester

16% Implementing practices to improve pollinator habitat

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
132	Weather and Climate

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
2016	8

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Wildlife resources contribute greatly to the bio-economy of Michigan, the US and the rest of the developed world. Yet, several significant and on-going demographic changes will dramatically affect the institution of wildlife management: the social landscape is becoming more diverse ethnically and racially, and suburban sprawl continues to grow into rural environments. Although wildlife in suburban-ex-urban settings has been a continual stewardship concern to wildlife professionals, only recently has the level of stakeholder interest in the issues and scrutiny of management become acute. Left unchecked in an increasingly suburbanized landscape, human-wildlife conflicts likely will become an insurmountable drain on agency personnel and financial resources. A potentially even more heinous effect, however, is that public perceptions of wildlife may transition from one of being a valued resource to one of pest . If this occurs, societal support will dwindle for wildlife conservation generally.

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
Researchers developed a user-friendly program that simulates how incidence of malaria/human risk of malaria in African community changes over time in relation to changes in climate and socioeconomics. The user interface and the model running the simulation are complete and the associated manual and lab workbook are being developed.

A change in knowledge and practice occurred in regards to management of white-tailed deer in suburban environments. Initial research results suggested localized approaches to conflict management would be more effective than broad-brushed approaches previous used by the Michigan Department of Natural Resources (MDNR). Maps, depicting isoclines of tolerance for deer were produced and reported to stakeholders. Insights into the characteristics of human communities with conflicts were described quantitatively and qualitatively in terms of landscape features, demographics, affluence, as well as the extent and quality of interactions with white-tailed deer. Knowledge transfer occurred through presentations to the MDNR Wildlife Division at

their annual division meeting as well as two separate regional meetings and extensive consultation with local area managers.

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources
135	Aquatic and Terrestrial Wildlife

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
2016	9548

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Home gardeners continue to strive to grow and produce healthy vegetables, lawns, soils, and garden for pollinators. Sustainable and earth friendly practices, i.e. smart gardening education, provides them with research-based methods that allow them to garden smarter, not harder and adapt environmentally savvy principles in their yards in gardens.

What has been done
In 2016 within the Upper Peninsula, 15 different Smart Gardening presentations were conducted in at least 7 different counties that focused around smart gardening topics of: Smart Gardening for Pollinators, Smart Gardening with Season Extenders, Smart Gardening: Building Healthy Soils, Smart Gardening with Small Fruit, Smart Gardening: Apple Tree Care & Pruning, and Smart Gardening Vertically with Pallets.

Results
Evaluation surveys at the end of the 2016 growing season were emailed to 186 total participants who provided email contacts. A total of 51 respondents (27%) provided responses to the following questions:
92% (n=47) responded that they improved their awareness/knowledge or intend to change your practices/improve your skills regarding sustainable gardening practices. The practices that they

adopted were:
63% planted a diversity of flowers that bloom throughout the growing season. (n=33)
60% mowed lawn at highest height and/or returned clippings to the lawn. (n=33)
60% selected flowering plants best suited for pollinators.

(n=33)
94% (n=48) responded that they improved their awareness/knowledge or intended to change their practices/improve their skills to reduce, eliminate or properly use pesticides. The practices that they adopted were:
53% selected resistant varieties (n=32)
50% used crop rotation (n=32)
94% (n=47) responded that they improved their awareness/knowledge or intended to change their practices/improved their skills regarding practices to reduce, eliminate, or properly use nutrients?
Practices they adopted/continued to use were:
48% create healthy soil, i.e. feed the soil to feed the plant (n=31)
39% apply organic material annually, i.e. mulched leaves (n=31)
81% (n=33) responded that they improved their awareness/knowledge of practices that will help them improve their garden?s yield, improve production yield or decrease their total inputs.
90% (n=33) responded that they adopted and/or continued to use practices that increased their yield, improve the quality, or decreased their inputs. Practices included:
67% continue to develop healthy soils, i.e. decreased tillage
40% proper plant selection
40% proper plant care, i.e. healthy plants are more resistant to pests and diseases

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
2016	6

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Humans affect aquatic ecosystems at a variety of levels, and across a wide range of spatial and temporal scales. The impact of human activities on aquatic ecosystems is often to reduce their productivity of "desirable" species, and to reduce the ability of the system to withstand additional perturbations. Applied research is needed to identify the consequences of specific actions (e.g., land use changes, lakeshore development, dam removal) and the mechanisms bringing about change. Basic research is needed to formulate models capable of synthesizing this information. Research linking fish populations to their habitat is essential for better managing our fishery resources in the face of increasing demand by the citizens of Michigan. As the fishery management profession has matured, it has become increasingly apparent that habitat management (often in partnership with terrestrial land managers) is needed to maintain productive aquatic ecosystems capable of providing sustained societal benefits and food resources.

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

ctivities include economic analyses and ongoing implementation of surveys of fishing site choices by anglers holding Michigan licenses, the development of travel cost valuation models for fishing sites and quality throughout Michigan and the Great Lakes; analyses of surveys of hunters; analysis of a survey of the public's willingness to pay to supply enhanced ecosystem services from agricultural lands through the adoption of low-input practices; the development and implementation
of travel cost valuation models for valuing beaches, beach access, and the damages from beach closures on the Great Lakes. Analyses also focussed on potential economic damages of invasive species.

Lake trout refuges in the Apostle Islands region of Lake Superior are analogous to the concept of marine protected areas. These refuges, established specifically for lake trout (Salvelinus namaycush) and closed to most forms of recreational and commercial fishing, were implicated as one of several management actions leading to successful rehabilitation of Lake Superior lake trout. To investigate the potential significant of Gulf Island Shoal and Devils Island Shoal refuges for populations of not only lake trout but also other fish species, relative abundances of lake trout, lake whitefish (Coregonus clupeaformis),
and cisco (Coregonus artedi) were compared between areas sampled inside versus outside of refuge boundaries. During 1982-2010, lake trout relative abundance was higher and increased faster inside the refuges, where lake trout fishing was prohibited, than outside the refuges. Over the same period, lake whitefish relative abundance increased faster inside than outside the refuges. Both evaluations provided clear evidence that refuges protected these species. In contrast, trends in
relative abundance of cisco, a prey item of lake trout, did not differ significantly between areas inside and outside the refuges.This result did not suggest indirect or cascading refuge effects due to changes in predator levels. Overall, this study highlights the potential of species-specific refuges to benefit other fish species beyond those that were the refuges' original target. Improved

understanding of refuge effects on multiple species of Great Lakes fishes can be valuable for developing rationales for refuge establishment and predicting associated fish community-level effects.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
134	Outdoor Recreation
135	Aquatic and Terrestrial Wildlife

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
2016	12

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
With growing concern about the connection between health and the marine environment, there is a corresponding emphasis on large freshwater lake ecosystems and human health. The Great Lakes serve as a highway for international maritime commerce and support a $1 billion per year recreational and commercial fishing industry. They also supply drinking water for more than 15 million people. Holding about 20 percent of the world's fresh surface water, the degradation of the Great Lakes ecosystem through chemical and biological contamination presents an enormous challenge for the future.

The invasive sea lamprey remains the most significant source of mortality for many large fishes of the Great Lakes and represents one of the greatest impediments to the restoration of the native food web and the many economic opportunities and ecosystem functions it provides to human society. The financial cost of applying pesticides to sea lamprey-producing streams across the Great Lakes basin is substantial, averaging $10-18 million per year and requiring the application of as much as 70,000 kg of lampricide. These costs constrain the contrl program to treatment of no more than approx. 100 streams per year of the 485 known infested streams (21%), and likely

underlie the programs failure to achieve suppression targets

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 3 rd 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.

We have completed analyses to identify associations between climate and thermal or hydrologic properties of stream habitats in 22 states of the northeastern United States. Based on these associations, we are using projected climate data to identify those stream habitats that may experience changes with climate that will affect water temperature or hydrology most important to stream fishes.

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
2016	4

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
When establishing, or reestablishing, turfgrass on performance fields it is important to eradicate difficult to control plant species. This project demonstrated one way to control these unwanted plant species.

Factors affecting spatial variability of soil carbon through the landscape, including topography and biomass inputs via cover crops. The specific accomplishments include quantitative assessments of the contribution of cover crops to soil C and N levels in topographically diverse agricultural terrain. We have summarized and analyzed the data collected in the past five years. The results demonstrate that within topographically diverse agricultural landscapes cover crop of cereal rye brings the most benefits in terms of soil C sequestration on eroded
slopes. Moreover, topographical slopes are also the areas where the rye cover crop had a minimal negative effect on soil nitrate levels, thus reducing potential negative impact on subsequent corn crop.

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
2016	7

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

The effect of contaminant sorption on bioavailability and hence exposure/ toxicity is needed to establish more realistic cleanup
criteria for soils and sediments such as those found at Superfund sites. Additionally, the use of sorbent amendments, as for example with activated carbon, to sequester contaminants in forms that reduce or eliminate bioavailability is an exciting new direction in the remediation of contaminated soils and sediments. We have shown for the first time that activated carbon can sequester 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in a form that eliminates its bioavailability to a mammalian (mouse) model. This supports the concept of using sorbent amendments as a new direction in the management of TCDD
contaminated soils/sediments, which offers cost savings compared to conventional technologies.

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
132	Weather and Climate
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
2016	7

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
Expansion of a Photosynthetic Phenomics Center at MSU. We established the MSU Center for Advanced Algal and Plant Phenotyping (CAAPP) to develop and apply transformative phenotyping technologies to enable us to directly address the next big challenges in plant biology, to establish MSU as an international innovation center and "international point of destination" for phenotyping analysis. In its first three years, the Center has established key instrumentation platforms and associated analytical software and approaches that start to bridge the gaps in our knowledge from genes to phenotype and from the lab
to the fields. As of Sept, 2016, more than 30 MSU faculty and researchers, from 11 departments and programs have used CAAPP
technologies and facilities including 14 different MSU AgBioResearch groups focusing on agricultural-relevant projects. CAAPP facilities have been used in an estimated 50 or more publications (both within and external to PRL), and its capabilities, direct involvement and preliminary data have contributed to more than 20 external grant proposals from MSU. From 2012-2015 over 14 grants were funded, totaling more than $46M, roughly $24M of that went to MSU. In the past year 10
additional grants were obtained by projects using the CAAPP facilities (totaling more than $4.0M) with an three additional proposals pending or in preparation including a major Bioenergy Resource Center . In addition CAAPP serves as a core facility for renewal of the PRL.

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
135	Aquatic and Terrestrial Wildlife

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 2015-16 fiscal year, ABR and MSUE were able to 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 600 in 2015. Project GREEEN funds supported operational upgrades including strategic network and system modernization, as well as routine weather network maintenance. Sixteen Enviro-weather stations were upgraded with new loggers and sensors in 2015-16. Two new stations were added to the Enviro-weather network: Deerfield in September 2015 and Elbridge/Hart in May 2016.

Project GREEEN funds are used by the Land Management Office to help keep MSU AgBioResearch centers operating at full capacity. Funds are often used for new equipment and skilled labor positions. Many research centers were able to provide maintenance and repair services to infrastructure in 2015-16 through Project GREEEN, as well as funding for field trials, pest management and more. Numerous research center projects also benefited from Project GREEEN dollars, including:

- Monitoring for invasive grape pests.
- Sweet cherry bacterial canker research.
- Spotted wing drosophila monitoring in fruit crops.
- Trevor Nichols Research Center field lab renovations.
- Clarksville Research Center asphalt replacement and repair.

Together, MSUE and ABR continue to serve as the primary research and development arm for the agriculture and food industries in Michigan, valued at more than $100 billion

annually.

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 MSUE evaluation results,

Master Gardener IPM

Issue (who cares and why)? we wanted to get an idea of how the master gardener classes had contributed to the trainees understanding of Integrated Pest Management and other environmentallty sound gardening practices, and whther they were likely to adopt these practices.
What has been done? a survey was distributed to master gardener trainess after they completed the training class in Ingham county (November 28, 2016) to determine the impact of the class on shaping their future gardening practices
Results/Impact? 82% of those responding to the survey felt that their gardening knowledge had increased significantly. 76% reported significantly increased knowledge about environmental stewardship practices and IPM practices. After completing the course, 95% felt confident that they would be able to find answers to gardening questions. A number of students mentioned practices that they planned to adopt in the upcoming growing season including getting soil tested, putting the right plant in the right place, mulching, proper fertilization and watering, and more. They reported learning about a variety of gardening skills during the Master Gardener classes.
What difference did it make - public value? Overall, students seemed very satisfied with the training that they received. 91% of the students filling out the survey said they were very likely to refer others to participate in the Master Gardener program. Additionally, as these Master Gardeners begin to volunteer on projects and share the knowledge gained with others the benefits are multiplied.
Another example,

Breakfast on the Farm

Issue (who cares and why)? In Southeast Michigan there is increased concern that farmers are partially responsible for algal blooms in the Lake Erie Basin. Non-farm public is putting public pressure on producers to change their manure and fertilizer practices (this is especially true for larger farms and CAFO's)
What has been done? At the Breakfast on the Farm in Lenawee county this year we incorporated a water quality educational station to demonstrate how farmers are taking steps to reduce the chances for polluting waterways. In addition, we worked with a dairy educator who developed additional signage including "Controlling Runoff", Improving Water Quality", "Liquid Manure Storage", "Manure Applications", "Silage leachate catch basin" and numerous "Soil Health" signs.
Results/Impact? On the exit survey, visitors were asked if they read or talked to someone about water quality during their farm visit. 55% of all respondents (179 of 326) AGREED or

STRONGLY AGREED indicating that yes, they did.
While 61.2% of 1st-timers and 58% all agree or strongly agree that dairy farmers contribute to water quality issues in our rivers and lakes, there was a shift in their level of trust that farmers will do the right thing to protect water quality from 73 for 1st-timers and 79% All respondents before the tour to 89 and 92% afterwards.
What difference did it make - public value? Providing education around this topic may reduce the amount of misinformation in the region. It will also increase the public's confidence that farmers will do the right thinking with regards for the environment.
Another example,
Provide a summary of impact.
Issue (who cares and why)? Water resources quality are impacted by a variety of activities. Educating both lakefront property owners, local officials and inland residents on their impact and responsibility to protect these resources is primary to having good quality surface and groundwater for recreation, economic development and quality of life.
What has been done? Former in person Intro to Lakes program was updated, and developed into a 6-week online course with powerpoint lectures, resources, discussion forums and live chat sessions

Results/Impact? Increase the number of people receiving this training over in person program and programs surveys indicate a higher level of knowledge and planned protection activities by course participants.
What difference did it make - public value?
The 2016 Intro to Lakes online course had 152 registrations from 42 Michigan counties and 8 other states (Connecticut (1), Illinois (1), Massachusetts (1), New York (1), Ohio (2), Pennsylvania (1) and Wisconsin (2). This is nearly a 50% increase over 2015. Participants indicated they were lakefront property owners, local elected officials, educators and lake professionals and citizens. 118 completed course and received certificates. Thirteen started but did not complete the course; 18 registered/paid but never logged into any sessions; 3 registered but never paid.
Over 87% rated their satisfaction with the course either high or very high. 85% said they planned to use the course information in future local management efforts. A number of participants requested course credits for 3 other program requirements: MDARD (17); Citizen Planner (33); SCECH (11).
Over 71% (72/101) said they had never participated in a MSUE program prior to taking Intro to Lakes and 98% indicated they would use MSUE for lake resources and training in the future.
Based on participant responses on the pre-course survey, a large percentage were knowledgeable or somewhat knowledgeable about environmental practices and activities. For example:

- 85% (106/124) said they volunteered time to a lake association, local conservation district, watershed council or their related organization. While 93% (93/100) indicated they planned to adopt this activity after taking course.
- 80% (99/124) said they participated in local water monitoring efforts while 87% (87/100) said they planned to participate in this activity after the course.
- 78% (97/124) of participants said they educated others about lake and stream stewardship prior to the course and 89% said they planned to educate others after the course.

In surveying about specific environmental practices:

- Conducting soil tests, purchasing phosphorus fertilizers, conducting regular septic system maintenance, diverting stormwater away from waterways all increased in planned

activities.
When asked about specific lakefront activities:

- 98% prior and 99% post course planned to avoid herbicides and pesticides in sensitive shoreline areas
- 93% pre and 95% post course planned to slow or divert stormwater from waterways
- 78% prior and 83% post course planned to maintain a no-mow zone along the shoreline of lakefront property
- 77% pre and 89% post course said they planned to maintain a natural shoreline (vegetation strip) along the water's edge to reduce runoff of chemicals and stormwater.

There was increase in both the number of discussion forum threads and replies to questions or comments in 2016 which was anticipated based on the increase in participants. The average forum posts read by each student was 40 with the average number of post 1.2 and average number of replies by students was 4.1.
The chat participation for the 3 live session ranged from 39% to 55%. The number of questions posed by chat participants doubled over 2015 numbers. The questions and answers were completed (not enough time for live replies to all questions) and posted on the course D2L site.

Key Items of Evaluation

MSUE Institute Work Team Adult Outputs in this area:

Institute for Agriculture and Agribusiness

4,214	AABI-01-Animal
10,659	AABI-03-Consumer Horticulture
8,417	AABI-04-Field Crops
3,484	AABI-05-Fruit
1,843	AABI-06-Ornamental Horticulture
1,785	AABI-07-Vegetable

Institute for Greening Michigan

3,547	GM-2. Natural Resources Stewardship
2,505	GM-3. Government and Public Policy
5,781	GM-5. Michigan Sea Grant
509	GM-7-Leadership and Community Engagement (LCE)

AgBioResearch Key Items:

HELPING SCIENTISTS COMMUNICATE, COLLABORATE AND ACHIEVE THEIR GOALS

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 re-sources, 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.
"The approach enabled students to understand where each team member was coming from as a scientist," said O'Rourke, professor in the MSU Department of Philosophy. "The hope was that developing this mutual understanding would make it easier for them to work together and make decisions collaboratively."
After publishing the results of the initial project, O'Rourke and his colleagues at the University of Idaho were able to secure financial support from the National Science Foundation to expand TDI to benefit the scientific community at large.
Story continued at: http://agbioresearch.msu.edu/news/publications/annual_report (pg 30)

DEVELOPING BIODEGRADABLE PLASTICS TO REDUCE NEGATIVE ENVIRONMENTAL IMPACTS
Around the dawn of the 20th century, scientists were hard at work developing one of the most influential products in history -- plastic. It was easily manufactured at a low cost and could be used for various purposes. Because of these desirable traits, plastic became a common material in the construction of just about everything.

The surge in plastic products continues today, but there's a catch: Its proliferation into virtually every market has created a surplus. 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
(MSU), believes this is a problem that can be solved through utilization of biodegradable and compostable materials.
Upon his hiring at MSU in 2004, Auras decided that a primary component of his research would be biodegradable plastics. First, Auras wanted to test the compostability and degradability of existing biopolymers. To do so, he needed a way to simulate several climate conditions in the lab.
Auras and his team have created a chamber that holds numerous samples, in which the temperature and other environmental conditions can be easily altered. Contained within each sample is soil -- home to microbes that break down the plastics -- and the biopolymer. Auras said that the initial stages of the research have highlighted the complexity surrounding this topic.

"There are a huge number of factors that go into the biodegradation of a biopolymer," Auras said. "We have to think about the chemical structure and facilitating the breaking down of that structure with the help of microbes. There are other important aspects -- temperature, pH and moisture levels. High-moisture environments encourage degradation, for example. When we think about developing new biopolymers, these are the things we're considering."

Auras believes that biodegradable plastics could revolutionize the food packaging industry.
Story continued at: http://agbioresearch.msu.edu/news/publications/annual_report (pg

26)

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%		5%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants	0%		11%	
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%		11%	
212	Pathogens and Nematodes Affecting Plants	0%		11%	
215	Biological Control of Pests Affecting Plants	0%		5%	
216	Integrated Pest Management Systems	10%		13%	
806	Youth Development	10%		2%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	29.6	0.0	20.0	0.0
Actual Paid	32.0	0.0	27.0	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**
1409091	0	2222124	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1409091	0	2187048	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	11825370	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?

Some examples of questions answered in the Ask an Expert can be found at https://ask.extension.org/users/198221 that addressed topics like:
Impact of honey bees on native bees
Agricultural Plat Map
Beginning beekeeping
Magnesium levels
Potatoes Not Producing
Sumac identification and use of pods in bee keeping
Protect Carpenter Bees
Bees
What is wrong with my tomato plants?
Mason Bee Tubes
Another example,
UAS Commodity of Practice group.
Learned and utilized information from the CoP regarding the use of drones and sensors in agriculture from a session called: Unmanned Aircraft in Agriculture Learning Network Webinar Series. These sessions also examined new drone regulations referred to as Part 107 (FAA). In addition, the MSUE staff member is the only known educator with the FAA Remote Pilot in Command certificate. In this capacity he helped other educators secure licences.

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	17081	51243	23538	75270

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

Patent Applications Submitted

Year:	2016
Actual:	19

Patents listed
MICL02133, The convergence and activation of abiotic and biotic stress signaling in plants, Serial Number 14/384,094; MICL02391, Evaluating the Specificity/Structure of Enzymes from a Taxus Plant, Serial Number 14/408,515; MICL02121, Molecular Genetic approaches to Improving Crop Production Efficiency, serial numbers 14/544,193, 14/544,194 , 14/544,192; MICL02141, Molecular Insights Into Geobacter Biofilms, Serial Number 14/705,766; MICL01810, Genetic Improvement of Strawberries and Blueberries, Serial Number 20142700, 20142702; MICL01654, Genetic Improvement of Bean (Phaseolus vulgaris L.) for Yield, Pest Resistance and Food Value, Serial Numbers 201500009, 201500008, 15-8734, 15-8735 ; MICL02357, Regulation of Lipid Metabolism in Plants and Algae, Serial Numbers 62/058,985, 14/598.953 ; MICL02368, Understanding Spatial and Temporal Variability of Crop Yield, Water and Nutrient Fluxes by Integrating Precision Agriculture with Crop Modeling, Serial Number 62/087,924; MICL02421, The Physiology and Biochemistry of Herbicide Action, Selectivity, and Degradation, Serial Number 62/129,124; MICL02364, Dynamic Environmental Photosynthetic Phenotyping for Mapping Responses of Crop Plants to Environmental Fluctuations, Serial numbers 62/154,405, 14/404,338; MICL02315, Exploring Sporulation and Spore Dispersal in Fungal Pathogens, Serial Number PCT/US2015/034543.

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	2	60	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research projects on plant sciences.

Year	Actual
2016	90

Output #2

Output Measure

- Number of adult participants trained in plant management systems.

Year	Actual
2016	15529

Output #3

Output Measure

- Number of youth participants trained in plant management systems.

Year	Actual
2016	23538

Output #4

Output Measure

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

Year	Actual
2016	1552

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
2016	1397

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example, the Michigan Blueberry Advisory Committee (MBBAC) has placed Integrated Pest Management issues at the top of its priorities for Research and Extension in 2016. That include the Spotted Wing Drosophila, Stem Gall Wasp, and Pesticide Resistance Management. However, the Spotted Wing Drosophila (SWD) remains as the number one issue for the industry. Since the SWD arrival in 2010, managing insect pest problems are increasingly difficult and costly for Michigan?s small fruit industry. In 2012, growers estimated in $23.9 and $2.7 million the economic losses caused by the SWD on the blueberry and raspberry industry. Hispanics reported losses due to SWD amounting up to 58% of their income. For the Amish community in 2013, most growers lost 50% of their raspberry and strawberry crops and they had to abandon to crop after unable to control the SWD infestations. In addition to crop losses, the cost of controlling the SWD increased from an average of $150 in 2012 to $372/acre in 2013.

What has been done
In 2016 we conducted 5 Twilight Meetings with berry growers and participated as speaker in one regional meeting, the 2016 Southwest Michigan Horticultural Days. Topics discussed at those gathering included: The use of pesticides and growers ?health, Insect pest and disease management updates, weed management issues. In addition, growers were presented with options to help them to re-tool their IPM programs to incorporate the SWD control. Under this activity we provide training and assistance to 181 berry grower, most of them blueberry growers. This included 14 Hispanics, 2 African American, and 165 Caucasian. Results by gender are 42 females and 139 males. Also, to assist growers with insect and disease management and pest ID, I conducted 287 farm visits during the crops season for blueberry, strawberry and raspberry growers. This included 23 visits to Amish growers and 52visits to Hispanic small fruit growers. In addition, 18 CAT Alert articles on Crop Management in general for blueberries, raspberriesand strawberries were published. In addition, one factsheet in Spanish ?El Manejo de la Mosca Drosófila de las Alas Manchadas (SWD) en los Arándanos de Michigan? Rufus Isaacs1, John

Wise1,2, Carlos Garcia-Salazar3, y Mark Longstroth. Edición, Revisión y Traducción al Castellano: Anamaría Gómez-Rodas y Carlos Garcia-Salazar. Publication is available at the MSU SWD IPM web site. Another publication was a Poster Presentation at the 2016 Great Lakes Fruit, Vegetable and Farm Market Expo; ?Pesticide Management Education: Key to making the most out of your spray applications against the spotted wing Drosophila (SWD)?. In total we produced 20 publications in support of the small fruit industry of Michigan.

Results

An end of season Survey Monkey among 450 growers and shippers indicated that crop losses due to insect problems at harvest was on average 4% of the blueberry harvested and processed. However A 65% had no crop losses and 35% reported losses averaging 11%. On average, insect pest control cost was reduced to $178/acre from $215/acre in 2015. Although application numbers remained the same as in 2015 due to adverse weather conditions, there was a $37/acre saving in pest control in comparison to 2015.

Considering the number of growers (179) participating in our educational programs in 2016 and the average number of acres per farm reported by the 2015 Michigan Fruit Inventory (37.4 acres), our program had a direct impact on 6,693 acres of blueberries. In 2016, the average blueberry yield was 4,700 lb/acre. Therefore, the volume of crop protected for 2016 was estimated in 31.4 million pound of blueberries with a market value of $38.9 million. Total savings in pest control were estimated in $247,641.

What difference did it make - public value?

Our IPM training program provides the means for small fruit growers to remain competitive despite the increase in production costs due to new invasive pest problems. In addition, technical assistance and education provided by the MSUE Small Fruit team ensures growers, farmworkers and consumer are not exposed to harmful levels of pesticides.

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
2016	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
American organic farmers represent only 1 percent of total U.S. farms, with 14,540 farms out of 2.2 million, and 4.1 million acres of land out of 922 million, with organic farms in all 50 states. Despite their smaller numbers, the sector grew by 8 percent in 2010, dramatically outpacing the food industry as a whole which grew at less than 1 percent in 2010. Overall, the industry has grown from $3.6 billion in 1997 to $29 billion in 2010, demonstrating that the organic sector will continue to play a contributing role in revitalizing America's economy through diversity in agriculture. Given this, research to help these producers increase production and marketing efficiencies and control pests with methods that conform to organic standards is critical.

What has been done
Research to: optimize the production and use of thermophilic compost and vermicompost as important tools for organic and sustainable production and management of vegetable transplants and high tunnels for year round vegetable production and marketing on rural and urban farms; and to develop a methodology for quantifying multi-trophic crop/pest beneficial interactions.

Results
Research Highlights: 1) Our prototype attract and kill device appears suitable for use on Japanese beetles and Oriental fruit moth but less so for codling moth and spotted wing drosophila. We are in the intial stages of evaluating it for brown marmorated stink bug. 2) Our 2 nd prototype SSCD system provided pest management consistent with air blast applications. 3) We have initiated projects evaluating the functional linkages between detritivore invertebrates and the breakdown of overwintering scab inoculum utilizing metagenomics and molecular gut content analysis. 4) We have begun evaluating the functional response of brown marmorated stink bug egg predators in the laboratory: crickets, grasshoppers, minute priate bugs and long horned grasshoppers all feed on egg masses in the lab, earwigs, spined soldier bug and ladybird beetles do not. 5) Spinosyn based NOP compliant pesticides remain the best option for organic growers seeking to manage spotted wing
drosophila although we have begun culturing native strains entomoathogenic nematodes for evaluation as potential biopesticides. In addition we developed and validated a molecular gut content technique for predators of the plum curculio.

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
2016	16

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Biological control is the use of living organisms to suppress pest populations, making them less damaging than they would be otherwise. Biological control can be used against all types of pests, such as vertebrates, plant pathogens, weeds and insects. Insects that were of little economic importance can become damaging pests. When a non-toxic control method is used, natural enemies are more likely to survive and reduce the numbers and damage of potential pest species

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
Numerous species of fungus-like organisms called oomycetes cause soybean seedling blight. Symptoms of infection include rotten seeds or seedlings and lesions on living plants. Moist soils are prone to seedling blight, but the disease occurs in a number of climates.

To determine the prevalence of oomycetes across the soybean belt, including Michigan, samples were collected by research collaborators from the 11 states and sent to the Chilvers lab for analysis. Chilvers and his team identified a total of 84 species of oomycetes using DNA sequencing and characterized these species for their ability to cause disease. Chilvers found that the oomycete composition varied by region, with those in Michigan being similar to ones in

adjacent states.

Cherries occupy a critical space in Michigan?s fruit production portfolio with an industry valued at nearly $100 million per year. Cherry research is conducted around the state by MSU scientists, particularly at the Northwest Michigan Horticulture Research Center (NWMHRC) in Traverse City, Michigan, and the Trevor Nichols Research Center (TNRC) in Fennville, Michigan.

These two locations are where Gut and Nikki Rothwell, the center coordinator for NWMHRC and an extension specialist, have been conducting a series of pesticide efficacy trials for SWD. Thin skin on tart and sweet cherries makes them particularly vulnerable. When SWD found its way to Michigan, Rothwell hoped cherry growers could avoid an unmanageable population.

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
2016	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

The evaluation of the long-term impacts of soil and crop management strategies on crop production under climate change. Significant differences in both crop yield and soil nitrate accumulation were found between simulations with continuous vs annually reinitialized as commonly done. The decline of soil carbon with increasing temperatures poses additional threats to crop yields exacerbating the negative effects of climate change on food security and environmental degradation. We have collected over 8000 images over 220 fields across the Midwest to monitor and model spatial and temporal variation
of crop growth, water and nitrogen use, and yield at the field level. Field data have been collected to validate the model and to
ground truth remote sensing images. Development of vegetative indices based on remote sensing to relate to plant growth parameters has been underway since 2000 and these indices are used to estimate leaf area, biomass, leaf chlorophyll, and yield and can be used to evaluate the spatial variation in production fields. These results are being assembled into research reports to provide a base for developing water and climate-smart agricultural systems for the Midwest.

New knowledge on the effects of tillage on several vegetables was generated from research trials. This year, we found that sweet corn under strip tillage (ST) with rye or hairy vetch residue appeared to have reduced early vigor compared to full-width tillage (FWT). In snap beans and cabbage, ST in combination with rye or rye-vetch cover crops produced comparable yields to FWT, with reductions in tillage costs and improvements in soil moisture retention

We collected approximately 5800 seed from directed crosses in spring 2016 using 27 parental combinations of peach and nectarine. Parents used in crosses were preferentially chosen from those identified to be homozygous for bacterial spot resistance at locus G6xap. Another set of 120 elites, potential parents, and commercial varieties were subjected to PCR analysis of G6XapF resistance locus in fall 2016. These data combined with field ratings of bacterial spot symptoms will be used to publicize information to the commercial fruit industry about varietal resistance and to guide future breeding program work. We have identified 23 high quality peach elites from the breeding program homozygous for resistance at the G6XapF locus, which confers fruit resistance to bacterial spot.
We continue to evaluate Northern Gem as a potential peach rootstock for the Michigan climate. It shows good compatibility with common peach cultivars, moderate vigor. Seed trees are precocious, and productive. The one drawback so far is that foliage and growth characteristics are not conspicuously different from standard peach cultivars, and thus it will be more difficult to detect "misses" in the budding nursery.

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
2016	20

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
Efforts to develop genomics based resources for members of the Solanaceae family continued during the reporting period.
The transcriptome data generated through this project for three Petunia species, including the progenitors of the important crop plant Petunia hybrida, was utilized in the annotation of two Petunia genomes. In turn, the availability of the draft genome assemblies of these two Petunia species facilitated our study of the comparative evolution of acylsugar biosynthesis in tomato and Petunia (major goal 7). Acylsugars, are agriculturally useful insect repellants and the targets of breeding in important crop plants such as tomato and potato. Our analyses suggests that acylsugar biosynthesis is not completely conserved between
tomato and petunia and we have identified gene presence and absence variation as well as the evolution of new biochemical activities. These discoveries may facilitate engineering of novel acylsugar profiles in crop plants with improved insect resistance.

we developed a manuscript on mapping invasive rangeland species with remote sensing and submitted another on microbial ecology in invaded grasslands. we published one article on virus detection in wild plants and one review article on the effects of crop viruses on wild plants, and submitted one manuscript on the fitness effects of viruses on native plants. We processed vegetation samples for virus detection from a large landscape experiment, and collected vectors for further analysis.

We identified a new enzyme that works upstream of the BAHD enzymes described in the goals of the project. This enzyme was isolated from a bacterial organism not associated with the plant from which the BAHD enzymes were isolated. The enzyme converts phenylisoserine to phenylisoserinyl CoA that is used by the O-phenylpropanoyl transferase BAHD enzyme needed to make paclitaxel biosynthetically.

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
205	Plant Management Systems
206	Basic Plant Biology

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
2016	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Research on plant resistance to environmental stress is essential to sustainable agriculture. Determining how to develop or enhance resistance is a critical research area. Before plant varieties that are insect- or disease-resistant can be developed, scientists have to find a source of plant resistance and then determine how to cross-breed plants or isolate the responsible genes and then move them from one plant to another.

What has been done
Research to: better understand disease resistance signaling in plants; determine foliage thresholds based on the assimilation and storage of carbon; improve the efficiency of crop production through increased understanding of the genetics controlling plant growth and development; determine the effects of stress on plant metabolism; and to understand the genetic mechanism by which plants tolerate environmental stresses.

Results
This year we have continued to characterize the function and structure of secretory organelles. We have established fundamental mechanisms by which the identity of the network of the endoplasmic reticulum is maintained and we also found that the endoplasmic reticulum is in close association with endosomes. We discovered that defects in the structure of the endoplasmic reticulum hamper the movement of endosomes and affects their function in endocytosis, providing evidence that
defects in the structure of the endoplasmic reticulum can affect the function of heterotypic organelles. In addition we have analyzed the contribution of the extracellular matrix on the fundamental process of photosynthesis. By employing mutants of the cell wall with defects in the quantity and quality of a critical component, pectin, we demonstrated that photosynthesis is negatively affected by defects in the cell wall. These findings provide experimental evidence that the extracellular environment of the light harvesting tissues influences chloroplast functions.

Our findings on environmental niche (niche models or species distribution models) in three closely related species of Phlox,
all with cytotypic variation, provides important insight into the question of the predictability of the effects of polyploidy, aka the
"polyploidy paradigm". Our results suggest that polyploidization does not have predictable effects on ecology in a system where the species are genetically, phylogenetically, and ecologically, similar. This does not support a polyploidy paradigm.

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
2016	12

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Agriculture is Michigan's No. 2 industry. The state's agrifood system accounts for $71.3 billion in total economic activity and 600,000 jobs. Michigan is also one of the most diverse agricultural industries in the United States, growing more than 200 commodities. As the world population increases and demand for food and fuel relies more heavily on agricultural products, efficient methods of plant transformation will be required. Developing improved crop varieties is critical to sustaining an economically viable agriculture industry.

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

We continued our analysis of how different (existing) management practices affect species composition and productivity in perennial grasslands likely to serve as cellulosic biomass sources of biofuels and the impacts on diversity. We submitted results from a 3 year field experiment designed to examine how harvest time and frequency impacted biomass production and species composition in mixed species grasslands and it has been accepted for publication in Biomass and Bioenergy
(Stahlheber et al 2016). We also contributed to a review paper (Landis et al 201x, in review) summarizing results from the cross-site analysis of biodiversity and ecosystem services in alternative bioenergy crops. We continued a project developed in collaboration with S. Emery (U Louisville), funded by USDA to determine the impacts of N-fertilization and reduced precipitation (drought) on mycorrhizal community composition and growth of two varieties of Panicum virgatum, that are used
widely in the upper Midwest as potential bioenergy stocks. This experiment is established at the LTER BioEnergy plots and
will continue for another year. A followup proposal to USDA to explore these interactions on marginal lands was submitted in July 2016 (co-PIs: Stahlheber - UW Green Bay and Emery - U Louiville; KL Gross collaborator). We also completed a comparison of physiological, morphological traits among 11 cultivars of P. virgatum established at the KBS GLBRC intensive plots and are working on a manuscript summarizing these results as background for a trait-based analysis of whether combinations of switch grass species may be more productive (or resilient to environmental disruptions) than monocultures. A preliminary experiment was conducted this summer in collaboration with undergraduate researchers supported by the KBS NSF funded REU site grant and an undergraduate research program at KBS funded by the GLBRC.

This research is important in the context of soil sustainability and productivity. Food production has doubled in the last 40 years, mainly due to improved crop varieties, more effective pest resistance, greater water subsidies and increased fertilizer inputs, but in order to keep pace with human population growth, food production must again double in the next 40 years. A large proportion of land suitable for agriculture is already in use so we must look for other means of increasing crop
production to meet future demands. One of the ways in which we can begin to meet future demands, while simultaneously creating more sustainable agricultural systems, is by focusing on soil health. One critical aspect of a healthy soil is nutrient provisioning or the ability to provide nutrients in support of plant growth. This research provides information about microbial communities and their contributions to organic matter decomposition and soil organic matter (SOM) formation that is critical
for understanding soil health and more specifically, nutrient provisioning. Understanding the controls on SOM break-down and formation is critical because SOM is the foundation of a healthy, fertile soil, driving multiple soil functions. In addition to storing the largest fraction of terrestrial organic carbon and acting as a nutrient reservoir, SOM influences soil structure, water holding capacity, pH, ion exchange capacity, and soil biological activity. All of these factors in turn determine soil fertility, or the ability of soils to provide water and nutrients in support of plant growth. These data will ultimately help us design management practices that effectively optimize microbial contributions to crop nutrient availability and use efficiency.

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
2016	13976

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example in this area: Forages for livestock feed include alfalfa, grass, corn silage, and pastures. In 2015, Michigan had 970,000 acres for hay, 41,097 acres for pasture, and 260,000 acres for corn silage totaling 1,271,097. Forages are the third largest commodity crop in Michigan after corn and soybeans and represented $417,570,000 in revenue for farmers in 2015. Forages are also an integral part of the dairy, beef, horse, sheep and other small ruminant industries in Michigan.

In the last decade, farmers? yields have not significantly improved and averaged 2.68 ton/acre according to USDA NASS. The state forage yield average roughly ½ the yield compared to the yields in the MSU 2015 Michigan Forage Variety Test Report.

Farmers that are able to improve forage yield and quality are better able to improve production efficiency.

What has been done
To meet the need of farmers to improve production efficiency, the MSU Extension Forage Team initiated a series of meetings to provide the latest research and demonstration information

available for forage producers in Michigan. The educational meetings helped farmers learn about production practices to increase yield, improve quality, or decrease inputs.

Results
As a result of these meetings the following indicators, outcomes, and anticipated changes were observed:
-78 farms were represented from 30 Michigan counties
-62 post meeting evaluations were collected (73% farmers, n=45)
- o33,711 acres were represented
- o10,083 acres of alfalfa/hay ? 30%
- o4,700 acres of corn silage ? 14%
- o3,195 acres of pasture ? 10%
- o1,765 acres of cover crops ? 5%
- o13,575 acres of other field crops

- 12,310 head of livestock
- o9,790 dairy
- o559 beef cow/calf
- o1,444 beef feedlot
- o517 small ruminants

- 57% of participants (n=41) indicated that they would change their alfalfa fertility strategy to include sulfur (a limiting soil nutrient in many parts of Michigan - Michigan alfalfa tissue test survey provides fertility snap-shot
- 60% of respondents (n=12) that have bunk silos indicated that they would implement safety procedures and share the information learned with all silage personnel annually.
- 92% of respondents (n=54) indicated that their knowledge ? attitudes- skills were improved at least moderately as a result of the information shared at the meeting.
- 19% (n=11) indicated great improvement
- 63% (n=37) indicated good improvement
- 10% (n=6) indicated moderate improvement
- 8% (n=5) indicated slight improvement
- 27% of all acres (n=8,983) - Participants indicated they would implement management changes based on the information presented at the meeting.
- $82,530 ($9.19 / acre) is the value the management changes represent for increased revenue or savings.

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
2016	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Weed control is an essential part of all crop production systems. Weeds reduce yields by competing with crops for water, nutrients and sunlight. Weeds may also reduce profits by hindering harvest operations, lowering crop quality and producing chemicals harmful to crop plants. Weeds left uncontrolled may harbor insects and diseases and produce seed or rootstocks that infest fields and affect future crops. Weeds are a major source of yield loss for growers in Michigan and in the North Central Region. It is estimated that losses due to weeds left uncontrolled exceed $7.5 billion in the United States.

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
We completed laboratory studies to determine how seed persistence was influenced by soil amendments. We used six different amended soil treatments and completed a three month incubation study with three weed species. Our results were confounded by seed germination along the edges of the soil cores. To complete the study we must bury the seeds in larger soil cores to preclude germination.
We initiated research on the influence of interseeded cover crops in maize in summer 2015. We studied cover crop establishment at seeding times ranging from V1 through V7 in corn. Cover crops studied included radish, annual ryegrass, crimson clover, and a mixture of the three species. We measured cover crop density, biomass, corn yield and corn test weight

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
2016	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
Understanding whether or not the same soil groups have similar or different biological structure in different temperature zones
is critical to developing scalable soil health management strategies. We compared a soil type and a soil group based information to assess the scalability issue. First, we tested over two growing seasons how cover (mustard and oilseed radish), rotation (maize and soybean) and sugar beet crops affect soil health in sandy clay loam and loam types. Neither soil type had optimum soil food web structure for agroecosystem and the sandy clay loam soil was more stressed than the loam soil.
Across crops the results were not the same within or in both soil types, suggesting distinct interactions. The second study focused on exploring basis for scalability across Udalfs, Psamments and Saprists soil sub-orders (major agricultural soils with contrasting properties)

within the 40.1-45.0 o F and 45.1-50.0 o F temperature zones. Soil samples were collected from natural (pristine forests and other vegetation) and disturbed (agricultural soils with altered biological functions and soil nutrients) landscapes in the northeast and southwest regions which are separated by about 300 miles. Within each landscape, 2-3 fields were selected and 5-10 geo-referenced samples per field were collected from 0-30 cm depth. Soil food web structure varied by temperature zone and/or soil group. Principal component analyses of the measured parameters showed distinct correlation patterns among soil groups, by soil group within a temperature zone, by depth of sampling and/or landscape. A combination of the studies strongly suggests moving to a location- or regional-specific than a one-size-fits-all approach in order to effectively address soil health management strategies.

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
2016	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The wholesale value of floriculture crops produced in Michigan is more than $400 million annually. Michigan's 625 commercial floriculture companies showed an estimated value of $402.7 million, with over half of them reporting wholesale sales of more than $100,000. Total greenhouse cover is about 50 million square feet, with an additional 3,600+ acres of open ground for floriculture production. Research in this area is critical to keeping this industry viable and profitable.

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
48 planetrees from #25 containers were planted in a 3×2 factorial of root-ball manipulation and mulch (no mulch or 8 cm of ground pine park mulch). Fertilization did not increase height or caliper growth
after two years ($p>0.05$) but increased ($p<0.05$) leaf SPAD chlorophyll index. Both root-ball treatments increased new root growth relative to the control. Shaving the root-ball increased new root growth by 67% compared to the control trees; whereas teasing apart the root-ball increased new root growth by 49% relative to control. Mulching consistently increased soil moisture at 0-15 cm and 0-45 cm depth and increased tree caliper and height growth. The results indicate that root-ball manipulation at planting can enhance new root growth. Mulching greatly improved soil moisture availability and growth after transplanting, whereas fertilization had only a modest impact on post-transplanting tree performance.

Teacher training on science explorations using a science model as a guide is resulting in changes in teacher attitudes toward, and approaches to, teaching science at the pre-school and elementary level. Teachers are more comfortable with science and are approaching it as interesting discovery that happens every day. They are grasping the concept that science is "asking questions and discovering answers". We are also focusing on Next Generation Science Standards (NGSS) guiding questions as the basis for field trip explorations which has been enthusastically embraced by teachers.
We are changing the way teachers teach science, how they integrate field trips into the curricula and how they and their students connect to scientists. We are sowing the seeds of a new generation of scientists that are connected to MSU and to each other. Our unique technology integration efforts are serving as the model for gardens and schools throughout the country.

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
2016	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
We have determined that the rotary-tine harvester is a very effective and efficient device for removing fruit with little damage to the canopy and fruit of tart cherries. Summer hedging and root pruning are demonstrating significant canopy vigor reduction with little sacrifice to fruit production. Extrapolated on a per acre basis, cropping in the 4th, 5th and 6th growing seasons surpasses average state production for mature trees.

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 2015-16 fiscal year, ABR and MSUE were able to 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 600 in 2015. Project GREEEN funds supported operational upgrades including strategic network and system modernization, as well as routine weather network maintenance. Sixteen Enviro-weather stations were upgraded with new loggers and sensors in 2015-16. Two new stations were added to the Enviro-weather network: Deerfield in September 2015 and Elbridge/Hart in May 2016.

Project GREEEN funds are used by the Land Management Office to help keep MSU AgBioResearch centers operating at full capacity. Funds are often used for new equipment and skilled labor positions. Many research centers were able to provide maintenance and repair services to infrastructure in 2015-16 through Project GREEEN, as well as funding for field trials, pest management and more. Numerous research center projects also benefited from Project GREEEN dollars, including:

- Monitoring for invasive grape pests.
- Sweet cherry bacterial canker research.
- Spotted wing drosophila monitoring in fruit crops.
- Trevor Nichols Research Center field lab renovations.
- Clarksville Research Center asphalt replacement and repair.

Together, MSUE and ABR continue to serve as the primary research and development arm for the agriculture and food industries in Michigan, valued at more than $100 billion annually.

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 MSUE evaluation results are:

Beginning Farmer Webinar Series

ISSUE
Michigan citizens interested in engaging in new agricultural enterprises sometimes lack knowledge, experience and technical support to get started. Extension educators and specialists receive numerous contacts from such people seeking basic, start-up information. The Michigan State University Extension Beginning Farmer Webinar Series was developed in response to this need.
WHAT'S BEEN DONE
The series continued for its fifth year in 2016 using the newly adopted Zoom Webinar platform. The 2016 series featured twenty four evening webinars from January 18 through May 2 on topics of interest to beginning farmers. Twenty seven MSU presenters were involved. Nine MSU Extension educators assisted as webinar 'hosts', providing pre-webinar support to presenters and 'live' hosting function. The series was promoted through MSU Extension local channels, MSU ANR Communications and eXtension. Two hundred thirty six participants registered for 1,686 webinar views, including one hundred eight five people from sixty three Michigan counties, forty six people from nineteen states outside Michigan, four from Canada and one from Turkey.
RESULTS
A follow-up on-line evaluation was conducted using Survey Monkey after the series was completed. Ninety responses were collected for a response rate of 38%.
72% of respondents indicated that the series was a very valuable use of their time. 28% indicated that it was somewhat valuable.
73% of respondents indicated 'very much' or 'quite a lot' of knowledge gained by participating. 23% indicated a 'moderate' amount of knowledge gained.
The total amount of agricultural land which respondents indicated is, or will be, influenced by what they learned from webinars is roughly 4,300 acres, with a median response of 2-4 acres and a mean response of roughly 50 acres.
As a result of the series, 84% of respondents will use the MSU Extension website and 81% will use the MSU Extension Beginning Farmer Webinar Series webpage. 64% indicated they will use printed MSU Extension materials and 63% indicated they will use MSU Extension educators and the local MSUE office.
Respondents indicated that they have, or will, diversify or expand an agri-food business or farm (48%), begin cultivating a crop in Michigan (46%), start up a new business (30%), purchase farm equipment (26%), begin a new livestock or poultry enterprise (23%), improve their standing at a current job or apply for a new job (16%), decide not to cultivate a crop in Michigan (15%), and establish new business partners (11%)
Ten respondents indicated that the series resulted in creation of new jobs.
DIFFERENCE
New farm businesses provide jobs, income and increased economic and social stability, and increased food security to rural and other communities. Providing basic, practical information to people interested in, or already engaging in, new farm enterprises helps these small businesses develop sound production and marketing plans.
Another example,

Smart Apple Care & Pruning

Need

Proper care and pruning of apple trees in home orchards and yards continues to be of interest to gardeners. A number of home owners either inherit or purchase property that contains a number of older apple trees that suffer from years of neglect; these home owners are interested in learning about to renovate and care for these trees. Home owners also annually purchase a number of new apple and fruit trees that they plant; they are interested in how to properly maintain and prune these trees.

Response

The Smart Apple Care & Pruning presentation included a hour power point with Q&A followed by a one hour outside hands on pruning workshop on a number of older and young apple trees.
A total of 32 participants completed the evaluation survey. 100% of these respondents noted that they are backyard hobbyist, and the number of apple trees owned ranged from one to over 300 for a home owner. Some other interests in fruit included feeding the deer and an Extension Master Gardener who attended wanting to help others learn in the future.

Results

Participants were surveyed on their current knowledge of apple tree care and pruning before and then, after the presentation. The following topics were included:
1) **apple tree selection** understanding increased by 60%
2) **apple tree planting and care** understanding increased by 87%
3) **apple pruning** understanding increased by 74%
4) **IPM understanding** increased by 49%

Participants were asked which, if any, of the following Smart Gardening practices will they continue or now include and 56% of respondents noted they will not spray with pesticides when there are flowers to protect pollinators, 53% of the respondents noted they will have a soil test taken and follow its recommendations, 44% noted they will use proper plant selection, i.e. select plants that are hardy to their zone, plant's needs match site conditions, and 41% noted IPM practices such as proper pest ide, removal of infected material.
Other comments/suggestions given: love this class/use of practical hands on, very helpful and informative
Another example,

2016 Field Crops Pest & Crop Management Update

Overview:

The 2016 Pest & Crop Management Update seminars were held in regional locations across Michigan. These programs were held in response related to team priorities and initiatives. The AABI Field Crops Team (MSU specialists and educators) programs are developed in part from an advisory group comprised of farmers and agribusinesses. The top three priorities for programming were soil management, profitability, and reducing production risks.
The Field Crops Team has a history of providing research-based knowledge to address the needs of field crop producers across Michigan. There has been a strong emphasis on building good working relationships with the clientele we serve.
This meeting addressed all of the top priorities and provided farmers and agribusinesses with the latest research results and recommendations for field crops weed, insect and disease control and crop fertilization to help producers prepare for the 2016 growing season.
In addition to the work of MSU Extension, Michigan field crop producers are supported by commodity organizations that engage in market development, research and outreach. These strategic partners (Michigan Soybean Promotion Committee, Michigan Corn, and Michigan Wheat) help offset expenses associated with the meetings by providing the MSU Field Crops Weed Guide to each participant in addition to other marketing and

promotional resources.

Demographics:

The meetings were held in January and February, 2016. The six regional locations were Alpena, Alma, Frankenmuth, Hamilton, Peck, and Dowagiac. 490 individuals attended the seminars. 46 counties had participants at the seminars.

The registered participants represent a significant portion of the corn, soybean and wheat acres being grown in Michigan.

- Corn acres - 463,359 (n=290 farms) representing 19.7% of all corn acres in Michigan
- Soybeans acres - 443,063 (n=280 farms) representing 21.8% of all soybean acres in Michigan
- Wheat acres - 224,168 (n=217 farms) representing 44.0 % of all wheat acres in Michigan

A post-meeting evaluation provided the Field Crops Team with a summary to reflect the demographics associated with the meetings.

257 evaluations were collected from all locations

- 77% (n=199) were farmers
- 7% (n=18) were farm employees
- 8% (n=21) were agribusinesses
- 4% (n=11) were government agencies
- 3% (n=5) were other
- 1% (n=3) were consultants

Respondents to the survey indicated the following information:

- The total number of acres for farmer acres farmed or directly impact was 212,286 acres (n=199).
- The average farm size was 862 acres.

- Wheat - 25,831 acres
- Corn - 75,289 acres
- Soybeans - 75,147 acres
- Hay/alfalfa - 13,821 acres
- Corn silage - 4,445 acres
- Sugar beets - 6,365 acres
- Other - 11,388 acres

Agribusinesses were also represented and reported the following information on the survey:

- The total number of acres they farmed or directly impacted was 265,450 acres.

- Wheat - 35,000 acres
- Corn - 96,000 acres
- Soybeans - 98,500 acres
- Hay/alfalfa - 7,700 acres
- Corn silage - 3,000 acres
- Sugar beets - 22,250 acres
- Other - 2,500 acres

Impacts:

A. Herbicide resistant weeds:

One of the major agriculture challenges farmers and agribusinesses are facing is the

growing threat of herbicide resistant weeds in all cropping systems. Because of this challenge, the incorporation of different sites of action for pre/post herbicide application use is recommended by the MSU Extension Field Crops Team.

In response to the information presented at the meeting, 17% (n=39) survey respondents indicated they will implement the following changes into their herbicide program. 73% (n=168) indicated they already use the strategy for their cropping system.

B. The use of neonicotinoid treated seed:

The use of an insecticide treated seed has seen significant increases in the last 10 years. The use of neonicotinoid insecticides on seed corn was discussed as one insecticide that growers could possibly use less often, if available, due to recent studies that support this point: yield benefits attributed to neonicotinoid seed treatments are inconsistent or absent and that neonicotinoid insecticide treated seeds are often being used as an 'insurance policy' against uncertain insect attack, rather than in response to a documented pest threat.

In response to the information presented at the meeting, 74% (n=117) of respondents indicated they would consider using seed corn not treated with neonicotinoid insecticides on their farm, with another 2% (n=3) uncertain.

C. Number of farms adopting new practices for improving production efficiencies

Number of acres adopting practices or tools that manage risks

Farmers indicted the willingness to make management changes on their farms (n=158) and the number of corresponding acres (n=43,600). The following breakdown of farms and acres by size were reported:

- 1 - 100 acres (n=36) Total acres = 1,800
- 101 - 300 acres (n=51) Total acres = 10,200
- 301 - 500 acres (n=29) Total acres = 11,600
- 501 - 750 acres (n=15) Total acres = 9,375
- 751 - 1,000 acres (n=15) Total acres = 13,125
- 1,000+ acres (n=12) Total acres = 12,800

D. Estimate of $/acre of increased revenue or savings that correspond to the above management changes for the future. The total $ value of increased revenue or savings indicated by respondents was $444,985.

Another example,

Field Crops Webinar Series

During the period of February 23rd - March 30th, 2015 MSU Extension offered six, weekly one-hour webinars as part of the third annual Field Crops Webinar Series. This program was designed by Marilyn Thelen, Jim Isleib, Bruce Mackellar and James DeDecker to share key 2015 field crop production points from MSUE AABI's traditional winter meetings with underserved audiences in a condensed distance-learning format.

The six webinars covered Malting Barley and Hops Production (Feb. 23rd with Ashley McFarland and Rob Sirrine), Integrated Management of White Mold (Mar. 2nd with Dr. Martin Chilvers), Nitrogen Management in Corn and Wheat (Mar. 9th with Dr. Kurt Steinke), Dry Bean Insect and Disease Management (Mar. 16th with Fred Springborn and Greg Varner), 2015 Weed Management Challenges (Mar. 23rd with Dr. Christy Sprague), and Michigan Corn Stover Harvest (Mar. 30th with Dennis Pennington). 132 individuals from 44 Michigan counties, seven other states and Ontario participated in the program.

In January 2016, a one year follow-up evaluation was administered to measure impact of the 2015 Field Crops Webinar Series. A $50 fuel giftcard drawing was offered as an incentive to increase participation in the survey. 65 individuals responded, generating a response rate of 49%. A full evaluation summary is attached, and impact summarized below.

• 62% (n=40) reported changing aspects of their farm operation (or recommendations to producers) as a result of information presented in the 2015 MSUE Field Crops Webinar Series

• 52% (n=34) reported making more money as a result of participation in the 2015 MSUE Field Crops Webinar Series (including increased revenues and/or reduced costs), totaling an estimated $86,750

• 38% (n=25) reported that information presented in the 2015 MSUE Field Crops Webinar Series contributed to increased crop yields on their farm (or the farms of those they advise)

• 35% (n=23) reported that information presented in the 2015 MSUE Field Crops Webinar Series contributed to increased crop quality on their farm (or the farms of those they advise

• 12% (n=8) reported that participation in the 2015 MSUE Field Crops Webinar Series contributed to, the creation of a new business or business enterprise

• 11% (n=7) reported that participation in the 2015 MSUE Field Crops Webinar Series resulted in, or contributed to, creation of new jobs or more hours for existing jobs

• 20% (n=13) reported that participation in the 2015 MSUE Field Crops Webinar Series led to a reduction in fertilizer use on their farm (or the farms of those they advise)

• 11% (n=7) reported that participation in the 2015 MSUE Field Crops Webinar Series led to a reduction in pesticide use on their farm (or the farms of those they advise)
Another example,

Cover Crops

MSU Extension Presque Isle County, in partnership with three Michigan Conservation Districts (Montmorency, Presque Isle and Alpena Counties), the Natural Resource Conservation Service (NRCS) and local field crop producers received $29,810 in grant funds from the Sustainable Agriculture Research & Education (SARE) Partnership Grant Program to investigate and demonstrate cooperative aerial seeding as a method of timely cover crop establishment on Northeast MI corn and soybean acres.

The Northeast Michigan Aerial Cover Crop Seeding Demonstrations project used aerial overseeding to establish cereal rye, an oat-radish blend and winter wheat in 662 acres of corn and soybeans prior to harvest in 2015. 400 acres were managed as research and demonstration sites highlighted by a comprehensive outreach campaign and series of four extension events. Events were designed to educate producers on the potential benefits and challenges of aerial cover crop overseeding.

In March of 2016, a follow-up evaluation survey was administered to measure impact of the project. 13 producers, 5 public agency staff, and 1 agribusiness professional responded to our evaluation survey. A full project report is attached, with impact summarized below.

The respondents reported managing or directly impacting 14,030 tillable acres in Northern Michigan. Of the 19 respondents 58% participated in our Aerial Seeding Workshop, 39% participated in our Aerial Seeding Field Tour and 37% participated in cooperative aerial seeding activities.

• Prior to initiation of our project in 2015, respondents reported planting an average of

86 acres to cover crops (1,375 acres total). In 2015, the average cover crop acreage per respondent increased to 108 acres (1,726 acres total).

- 83% (n=18) of respondents reported that participation in our project increased their knowledge of cover crops
- 46% (n=13) of respondents reported that they increased their use of cover crops as a result of our project
- 83% (n=18) of respondents reported that participation in our project increased their knowledge of aerial seeding technology
- 44% (n=18) of respondents rated aerial seeding as a favorable method of cover crop establishment for Northeast Michigan

Key Items of Evaluation

MSUE Institute Work Team Adult Outputs for this area:

Institute for Agriculture and Agribusiness

1,776 AABI-02. Business Management
10,659 AABI-03-Consumer Horticulture
8,417 AABI-04-Field Crops
3,484 AABI-05-Fruit
1,843 AABI-06-Ornamental Horticulture
1,785 AABI-07-Vegetable

Institute for Greening Michigan

6,594 GM-1. Community Food Systems
3,547 GM-2. Natural Resources Stewardship

Institute for Health and Nutrition

6,456 HN-2. Food Safety

Ag BioResearch Key Items:

Improving grain legume production with new ag technology

David Kramer's lab has developed a series of new tools that gauge living plants in the field and measure photosynthesis in real time. Using these tools, they found signals that could be used to indicate how efficient photosynthesis is, whether the plant is productive or if it's under stress, losing energy or being damaged.

But Kramer believes this emerging technology could be made even better.

"To really map genes so we can breed better plants," said Kramer. "We need to observe photosynthesis on many plants, under varying conditions--and then analyze the data. Plants, which are particularly sensitive to their environments, must be measured under the conditions in which they are actually grown. It's a massive undertaking."

The photosynthesis project is harnessing two new phenotyping technologies developed at MSU. One of these, the PhotosynQ platform, allows researchers, farmers and extension agents throughout the world access to sophisticated yet very inexpensive and easy-to-use instruments to measure reactions related to photosynthesis. This field-deployable network of handheld sensors and associated online communication and analysis tools enable researchers and farmers to conduct plant phenotyping experiments, analyze data and share results, and allow improvements in breeding and management on local and global scales.

"With these tools, we are now able to monitor many photosynthesis reactions in crops in multiple environments under natural conditions," said Dan TerAvest, a post-doc in Kramer's plant research lab. "Among the measurements we need to obtain in developing a stronger germplasm is photosynthesis regulation."

The second platform called Dynamic Environmental Phenotyping Imager (DEPI) simulates

field conditions in special chambers so that sophisticated imaging sensors from Kramer's lab can probe myriad plant processes and properties. For example, DEPI can measure how sensitive photosynthesis, growth, etc. are to specific weather conditions.
Developing DEPI and the PhotosynQ platform has been a major part of this project. With these technologies now available, distribution along with training and use of them has now shifted to the forefront. The goal of improving the robustness and efficiency of photosynthesis to accelerate the breeding efforts to improve grain legumes and germplasm can soon be explored.
Kramer's team has provided six handheld PhotosynQ MultispeQ units to Kamfwa's team to initiate the project's first field trials. They will study a gene platform in common bean plants that confer better performance under Zambian environmental stresses, looking for more resilient and productive traits.
"The key limiting factor of plant breeding is determining phenotypes, that is, the performance levels of particular traits in the field," said Kramer. "The technology we've developed determines which phenotypes are contributing to good or bad yield outcomes. We can map genes, but we don't know what the genes do. The MultiSpeQ and PhotosynQ can tell us that--and Kelvin is using the technology to that end in Zambia as part of his work to improve bean germplasm for better yields."
Using the MultispeQ and PhotosynQ, Kamfwa and his team in Zambia are beginning to develop rapid bean phenotyping protocols. Kamfwa's undergraduate and graduate students are using the PhotosynQ platform to find genes that let photosynthesis work more efficiently under combinations of agricultural limitations experienced in the region, including drought (and lack of irrigation), low soil nutrients (and the high cost of fertilizers in Africa) and various diseases.
For more on this story please visit: http://agbioresearch.msu.edu/news/publications/annual_report

GOING HIGH-TECH TO SOLVE LOW-TECH PROBLEMS
Insects have long threatened human health and crops. The tools used to combat that struggle vary from the humble fly swatter to complex chemical sprays and the introduction of rival insects to prey upon the pests. Today, Michigan State University
(MSU) AgBioResearch scientists continue to break new ground, developing and implementing new tools and methods to help better understand and combat insects.
MSU AgBioResearch entomologist Zsofia Szendrei has developed a plan to help Michigan farmers detect and fight against aster yellows, a chronic disease that afflicts over 300 species of herbaceous plants. In Michigan, the most common victims are celery and carrots. Growers in the state produce more than 59 million pounds of carrots, valued at over $12 million, and over 105 million pounds of celery, valued at almost $15 million.
Michigan ranks second in the nation for both vegetables, so aster yellows poses a significant threat to the state's agricultural industry. The disease is spread by the aster leafhopper, a tiny yellow-green insect that feeds on sap from plant leaves.
The pest itself does little damage to the plant, but as it feeds, bacterium-like organisms called phytoplasmas are injected into the leaves through the insect's saliva. Once infected, the plants experience a multitude of symptoms, including stunted growth, deformed growth, greening of flowers and reddening of foliage, which inhibits photosynthesis.
About 5 percent of leafhoppers carry the disease. Small outbreaks have resulted in significant yield reduction averaging 25 percent in carrots and occasionally rising as high as 80 percent.The only effective means of preventing outbreaks in either vegetable or ornamental crops is to reduce the leafhopper population through strategically timed pesticide applications. To do this, growers must accurately estimate both the number of leafhoppers in their fields and the level of aster yellows they carry with them. Four years

ago, Michigan vegetable growers came to Szendrei asking her to devise a predictive modeling system.

Szendrei partnered with a Michigan-based field scout, who travels virtually all of the celery acreage in the state to assess populations, to collect aster leafhoppers in the field. Once collected, the insects are stored in a portable freezer and delivered to MSU, where the high-tech work begins.

Using a molecular biology technology called polymerase chain reaction (PCR) -- which cleans up and amplifies samples of genetic code, allowing researchers to analyze it with greater clarity -- Szendrei's team developed a laboratory procedure that tests leafhopper specimens quickly and estimates the level of aster yellows in a field.

For more on this story please visit: http://agbioresearch.msu.edu/news/publications/annual_report

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%		10%	
603	Market Economics	0%		10%	
604	Marketing and Distribution Practices	5%		9%	
605	Natural Resource and Environmental Economics	0%		14%	
606	International Trade and Development	0%		11%	
608	Community Resource Planning and Development	20%		10%	
609	Economic Theory and Methods	0%		10%	
610	Domestic Policy Analysis	0%		11%	
611	Foreign Policy and Programs	0%		5%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	28.6	0.0	6.5	0.0
Actual Paid	26.0	0.0	11.0	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**
1162972	0	923804	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1162972	0	909222	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	4916165	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?

One example was,
Learning and then using information regarding Families and Inheritance: New and Proven Educational Resources and Strategies from the University of Minnesota.
Another example was,
Urban Development where using the Knight Foundation and Dr. C. Nicole Mason's framework of moving a community from isolation to interdependence, where MSUE and MSU worked with community partners to help them revitalize a very abandoned and blighted community through its support of economic development and policy development. MSU and MSUE assisted the City of Detroit with the first urban agriculture ordinance and is currently assisting with the first livestock ordinance.

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	12593	37779	0	0

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

Patent Applications Submitted

Year:	2016
Actual:	1

Patents listed
MICL02276, Designing Sustainable Bioenergy Systems, Serial number 14/579,377

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	2	20	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

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

Year	Actual
2016	37

Output #2

Output Measure

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

Year	Actual
2016	1674

Output #3

Output Measure

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

Year	Actual
2016	1068

Output #4

Output Measure

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

Year	Actual
2016	9851

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.

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
2016	1674

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Agriculture employers need up-to-date information on new labor laws and regulations that impact them.

What has been done
One example is the 2016 West Michigan Ag Labor meeting that assisted over 60 growers in complying with new labor laws and regulations that employed 364 part-time employees and 2213 part-time employees farming on over 10,000 acres.

Results
Evaluation results found: 100% stated they understood what is necessary to report an injury/illness; 95% planned on using the MSU Ag Labor Checklist; 92% reported being better prepared to comply with Work Protection Standards; 92% reported being better prepared to deal with the ACA employer mandate and Tax reporting requirements; and 82% gained knowledge about other potential sources of labor for their farm.

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
2016	1068

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Fundamental to the mission of MSU Extension 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 of more than $100 billion of economic activity every year that needs constant updating of information, consultation, and assistance to entrepreneurs and companies.

What has been done
On example, in the Spring, 2003 the Product Center was created with funds from the Michigan Agricultural Experiment Station and Michigan State University Extension to improve economic opportunities in the Michigan agriculture, food and natural resource sectors. The Product Center assist entrepreneurs and companies to develop and commercialize high value, consumer-responsive products and businesses in the agriculture and natural resource sectors by using MSU?s vast and varied technical expertise, research, outreach, and educational services. 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.

Results
In 2015-16, MSU Product Center professionals conducted 4,168
counseling sessions with 645 clients, resulting in: Nearly $40.5 million in total capital formation, including more than $9.4 million of owner capital investment in Michigan businesses. 62 new ventures launched. 324 jobs created or retained.

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
2016	8865

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example is newly elected County Commissioners need a solid foundation from which to work. The taxpayers of Michigan who demand quality services, the administrators, other county elected officials and staff care about how the county is managed and demand that county commissioners understand their roles and responsibilities. County commissioners want opportunities to network with other commissioners to learn about their jobs; Michigan Association of Counties (MAC) wants an opportunity to showcase their services. MSU Extension wants to provide research-based, unbiased information on the roles of commissioners, the latest financial information and be seen as a resource for commissioners to help them be successful as leaders in county government.

What has been done
Since 1968, MSUE and the MAC have offered an educational program for new county commissioners following the November election. That program has come to be known as the New County Commissioner Workshop, and has been offered every two years for nearly 50 years! This year, a team of MSUE educators offered New County Commissioner Workshop at seven locations around the state. The workshop consists of four hours of training on the fundamentals of county government and includes time for networking with other county officials, MAC staff, and MSUE educators and directors.

Results

A total of 213 people attended the workshops. Based on immediate post-workshop evaluation, 86 of reporting participants were newly elected county commissioners, 16 were commissioners for less than four years, 13 were commissioners for more than four years, 8 were county administrators or controllers, 9 were other elected officials or other county staff, and 8 were other types of participants.

Overall, 92% (n=120) indicated that they found the program valuable for their professional (or personal) growth and development.

When asked ?Compared to before taking the New County Commissioner Workshop:?

63% (n=115) reported feeling more or much more confident to describe sources of county revenues and major spending commitments within the county budget.
60% (n=116) reported feeling more or much more confident to effectively participate in your next public meeting.
64% (n=115) reported feeling more or much more confident to rely on their own knowledge and the input from staff to be an effective county official.
70% (n=115) reported feeling more or much more confident to distinguish between a court?s administrative responsibilities and the county?s.
68% (n=115) reported feeling more or much more confident to work in partnership with other county elected officials, court administrators, and department directors.
74% (n=115) reported feeling more or much more confident to network and ask questions of other commissioners in the region.
75% (n=109) reported feeling more or much more confident to successfully complete their term as an elected (or appointed) official.

What difference did it make - public value?

From maintaining records of property ownership to issuing marriage licenses to collecting and distributing taxes to providing a functional and effective justice system, county government is responsible for handling a diverse array of functions for Michigan residents. Every two years, the citizens elect county commissioners to develop policy and provide financial oversight to all aspects of county government. The role of a county commissioner is well defined by statute; however, understanding the relationships between the county board and other elected officials and department heads is very complicated. We are training commissioners so that they understand their roles within the complex system of county government.

MSU Extension?s government, leadership, and community engagement 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. Participants leave MSU Extension educational programs with:

a deeper understanding of their civic responsibilities and roles within their own communities;
increased confidence to make decisions;
skills and information to better manage community resources;
knowledge of how to implement best practices; and
understanding of the importance of building quality places in Michigan.

The application of knowledge and skills gained from good governance programs builds stronger civic infrastructure.

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
2016	19

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

During the reporting period, progress was made on simulating the projected impacts of weather and climate on corn yields for a future time frame, 2041-2070. We also completed an examination of the relative sources of variability and uncertainty associated with the various combinations of projected future climate.

We applied design criteria to our analysis of the sustainability of biogas and food coproduction on Italian farms as documented in the paper "Biogas Done Right..." It is possible to sustainably produce both food and energy from agriculture.
Accomplishments included receiving the Fred Buttel Outstanding Scholarly Achievement Award from the Rural Sociological Society for the book, "Concentration and Power in the Food System." In addition, peer-reviewed manuscripts were accepted by the journals Agriculture & Human Values (fair trade certifications), and Renewable Agriculture & Food Systems (consumer preferences for bird management practices in fruit). A chapter was submitted to a University of California Press edited book(seed industry consolidation), and a presidential address will be published in Agriculture & Human Values (diversity in the wheat and bread food system).

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
2016	11

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Recognizing, measuring, and managing risk is part of every-day practice for participants in the food system. Farmers and ranchers are subject to yield uncertainty caused by weather, pests, disease, and natural disasters. Price uncertainty, combined with biological lags between planting/investment decisions and harvest, imposes additional risks on producers. Food manufacturers and retailers face risks from higher input prices, emerging new technologies which alter the competitive landscape, and shifting consumer demand and price patterns. Consumers face risks of rising real food prices and resulting food insecurity, especially in developing countries but also among low income households in developed countries. All food system participants are exposed to the risk of changes in government policies which can alter the operation and performance of the system. Current trends in food system risks are not encouraging. Global warming appears to be adding to production uncertainties, perhaps increasing the frequency of natural disasters such as drought, flooding, hurricanes, etc. An effective response may call for major adjustments in production practices, marketing channels, and the spatial location of agricultural production. Moreover, since the global food price crisis of 2007/2008 there appears to have been a structural shift in world commodity markets causing prices to become both higher on average and more unstable. Increases in biofuel production, and uncertainty about the policy environment that has led to them, are additional new sources of risk. Food insecurity, especially for the poor, continues to pose major risks worldwide. Improvements in strategies and mechanisms for managing food system risks
can benefit participants and pave the way for more effective and efficient policy responses.

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
Weed management is a major challenge to crop farmers in the United States and abroad. We are writing a short economic analysis of the past century of weed management by U.S. crop farmers that contrasts the labor and capital requirements of alternative weed control practices (Swinton and Van Deynze, 2016 in prep).

Dairy farm financial performance based on profitability, solvency and liquidity assessed. Farm financial stress analyzed. The consequences and implications of poor milk basis in Michgian reflecting dairy processing capacity issues analyzed and communicated to stakeholders.

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
2016	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Management of personnel and human resources has changed over the past three decades, partially due to increasing employment legislation, education issues, employee awareness and changes in demographics. As competitors strive to win the war for talent, effective human resource management is necessary to gain true competitive advantage in the marketplace.

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
2016	5

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
Our research in Malawi was concluded with report pending approval by USAID. We found that traditional legume traders had three primary considerations to improve livelihood: 1) improve theft security at markets, 2) improve pest security at markets, 3) make transportation logistics simpler and less costly. This was shared both within Malawi and with USAID.

We derived information from rural-urban value chain studies in Indonesia on potatoes, tomatoes, and mangoes and Bangladesh and India on potatoes 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

2016 1

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

Curriculum on water quantity and water policy have been developed for Michigan State University Extension Water School,which will be piloted in November 2016.Target audience is state and local government elected and appointed officials.

4. Associated Knowledge Areas

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

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 2015-16 fiscal year, ABR and MSUE were able to 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 600 in 2015. Project GREEEN funds supported operational upgrades including strategic network and system modernization, as well as routine weather network maintenance. Sixteen Enviro-weather stations were upgraded with new loggers and sensors in 2015-16. Two new stations were added to the Enviro-weather network: Deerfield in September 2015 and Elbridge/Hart in May 2016.

Project GREEEN funds are used by the Land Management Office to help keep MSU AgBioResearch centers operating at full capacity. Funds are often used for new equipment and skilled labor positions. Many research centers were able to provide maintenance and repair services to infrastructure in 2015-16 through Project GREEEN, as well as funding for field trials, pest management and more. Numerous research center projects also benefited from Project GREEEN dollars, including:

- Monitoring for invasive grape pests.
- Sweet cherry bacterial canker research.
- Spotted wing drosophila monitoring in fruit crops.
- Trevor Nichols Research Center field lab renovations.
- Clarksville Research Center asphalt replacement and repair.

Together, MSUE and ABR continue to serve as the primary research and development arm for the agriculture and food industries in Michigan, valued at more than $100 billion annually.

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 evaluation results MSU Extension are:
Connecting Entrepreneurial Communities (CEC)
Issue (who cares and why?)
Michigan State University Extension believes that fostering entrepreneurship and community support are key strategies for creating jobs and transforming the state's economy and global presence. Michigan State University Extension has been involved in helping entrepreneurs grow their businesses for many years. The CEC program was created in Michigan approximately 10 years ago. It was launched in an effort to educate communities on the various tools and resources available to help them support and grow entrepreneurs in their communities.
What has been done?
To strengthen communities' support of entrepreneurs, the Greening Michigan Institute

organizes a statewide conference focusing on Connecting Entrepreneurial Communities (CEC) each year in October. The 2016 Conference was held in Port Huron on Oct. 5-6.
This unique conference was embedded in each community enabling attendees to explore and experience entrepreneurship throughout the event. Participants were energized after listening to the lessons learned by local entrepreneurs who served as keynote speakers. From there, they were able to see the community as they walked to their breakout sessions held in different venues including museums, coffee, furniture and other retail shops, restaurants, breweries, and chamber offices to name just a few. The event had over twenty different breakout sessions focusing on one of four tracks:

- **Growing an Entrepreneurial Community**
- **Youth as Entrepreneurs**
- **Arts, Ag, Food and Culture**
- **Green and Blue Economy (Sustainability & Natural Resources)**

After absorbing, acquiring and actively learning about the various entrepreneurship tools, resources and programs from the session breakouts, participants enjoyed a special networking event with cocktails and hors d'oeuvres. Participants had an opportunity to share successes and innovative programs, and to hear 3 keynote speakers.

Impact-Demographics

In 2016, all attendance records were broken with 139 individuals representing 5 states and 58 Michigan communities attending the CEC conference. When asked what sector the participants represented, their responses were as follows (N=48):

4.17% Agriculture
2.08% Arts and Culture
22.9% Economic Development
25% Education
10.4% Entrepreneur or Business Owner
22.9% Government Services
10.4% Non-profit Organization
2.08% Other

Impact - Knowledge Gain

The following are the results from the evaluation collected on-site and through an on-line survey for the conference (N=48)

97.9% of respondents reported **they Increased knowledge of business concepts, tools, skills, and resources to build entrepreneurship in their community**. Strongly Agree 47.9% Agree 50%
54.2% of respondents reported **an increase in knowledge of youth entrepreneurship resources and programs**. Strongly Agree 22.9% Agree 31.3%
76.6% of respondents reported **an Increased in knowledge of the value of ag, arts or cultural development as a useful economic development strategies**. Strongly Agree 27.7% Agree 48.9%
78.7% of respondents reported **they increased their knowledge of the value of tourism and/or the sustainable use of our natural resources as a useful economic development strategies**. Strongly Agree 40.4% Agree 38.3%

Impact-Intended Action

77.1% of respondents reported that as a result of the CEC conference, **they plan to create/expand at least one community based entrepreneurial activities and initiatives presented at the conference**. In the next 3-6 months: 29.2% In the next year: 47.9%
Another example,

Land Division Review Training and Planning & Zoning Primer Webinar

Issue (who cares and why)?

The Land Division Act is the Michigan statute for dividing property, establishing local government review and approval of splitting a parcel of land, and is the enabling statute for county, village, city or township land division and subdivision ordinances. It is one of the more complex Michigan statutes codified in law. Few organizations offer training on the topic and many local units of government do not follow a thorough procedure or do the necessary research to verify whether divisions or re-divisions are allowed when a request to do so is made.

What has been done?

Filling a void in educational materials and detailed training on the topic, MSU Extension (Kurt Schindler) developed a detailed training program on the topic for land division review officials (assessors and zoning administrators) years ago. More recently, Extension (Brad Neumann) modified the program to accommodate Michigan State Tax Commission (STC) requirements for offering continuing education for tax assessors. The program has been offered with STC continuing education credits three times since July 2012. Most recently, Schindler and Neumann offered the training in a webinar format comprised of three separate sessions spread over three days. The training was offered September 28, 29, and 30, 2016 via Zoom Webinar with 41 participants.

Results/Impact?

A post session evaluation was distributed electronically using Qualtrics. Results to date reveal:

- 93% (n=31) agreed or strongly agreed with the statement "Overall, I found this training valuable for my professional growth and development."
- 77% (n=31) reported their knowledge of legal responsibilities and limitations of their role in reviewing land divisions and/or zoning requests increased a moderate amount or a great deal compared to before the training.
- 77% (n=31) reported their skills to use information (from landowner applications and elsewhere) to make better development review decisions increased a moderate amount or a great deal compared to before the training.
- 71% (n=31) reported their confidence to apply state laws, such as the Land Division Act or Zoning Enabling Act, to their work increased a moderate amount or a great deal compared to before the training.
- 71% (n=31) reported their knowledge of where to locate quality informational resources related to zoning and/or land division / subdivision increased a moderate amount or a great deal compared to before the training.
- 68% (n=31) reported their confidence to suggest new or improved standards or review procedures for their local government increased a moderate amount or a great deal compared to before the training.

What difference did it make - public value?

The Land Division Review Training and Planning & Zoning Primer Webinar helps local government officials do their jobs more effectively through heightened knowledge of legal requirements and limitations, improved information and records, and increased confidence to suggest new procedures. Improved knowledge, more complete information, and increased confidence helps local officials run a community development department with more consistent treatment of customers, more administratively sound decisions, and reduced legal risk. In short, through this MSUE program, local officials are given the information and tools they need to positively affect the vitality of their cities, villages, townships, counties and the whole state.

Another example,

Leaders in Economic Alliance Development (LEAD)

Relevance

Communities are stronger when they work together. Communities that work together are able to leverage more expertise and resources to improve their economic development efforts and spur regional growth, which benefits a wide range of people. Often, the biggest challenge in getting communities to work together is the development of partnerships and leadership skills. LEAD is designed to build capacity in counties or regions through a short partnership development and planning process that enables local residents to accomplish a goal. The purpose of LEAD is to accomplish specific tasks during each session that will lead toward the development of leadership skills and an action plan that can be implemented by the team.

Leaders - Focuses on building and strengthening leadership skills in the community

Economic - Concentrates on opportunities to enhance the local economy

Alliance - Fosters the development of new partnerships within the community

Development - Gets things done!

Response

From late summer through the end of 2016, Mason, Lake, Newaygo, and Oceana counties participated in the LEAD program, facilitated by MSU Extension in partnership with USDA Rural Development. Participants took part in four sessions, one in each of the four counties, each with a specific goal. Session 1 focused on identifying key team members. Session 2 included identifying key participants for the Civic Forum and planning the Civic Forum. The third session was the Civic Forum, where community members from all four counties were invited and MSU Extension staff facilitated a process to help community members determine opportunities to prioritize and pursue. The goal of Session 4 was to create an implementation plan to achieve the goals developed at the Civic Forum.

MSU Extension staff that facilitated the LEAD program included Bill Hendrian, Ryan Coffey, Eric Walcott, and Kurt Schindler.

In total, 109 participants participated in the LEAD sessions, including 64 at the Civic Forum held at the Hart Community Center in Oceana County. The civic forum was the highlight of the LEAD process, with community members from all over the four counties coming together to identify and prioritize opportunities for collaborative economic development efforts.

Results

Based on the priorities decided on at the Civic Forum, the four counties decided to move forward with collaboration in three areas: Recreation and Trails, Workforce Development, and Broadband Infrastructure. At the final LEAD session of 2016, subcommittees focused in each area began the development of the action plan and made plans for future subcommittee meetings. MSU Extension staff and USDA RD will continue to work with each subcommittee in 2017 to facilitate accomplishing each goal.

Another example,

World Food Prize - Michigan Youth Institute 2016

Audience

This program is open to Michigan high school teens interested in topics related to global food security and food access. It is an MSU pre-college program that engaged youth leaders in dialogue around complex world issues, while introducing them to campus, MSU research efforts, and faculty experts. Total attendance was 29 youth plus 11 adults serving in a mentor-like capacity from[#] Michigan counties. Additionally, there were over 30 faculty and community adult volunteers serving as content experts at this event. Ages reached, as self-reported on program evaluations, were: 13- 4%, 14-17%, 15-49%, 16-13%, 17-17%; 65% were female and 35% male. People of minority populations comprised 9% of youth participants.

Objectives

The World Food Prize Michigan Youth Institute (WFP MIYI) is a one day event held at Michigan State University (MSU) where high school youth:

- Present research and recommendations on how to solve key global challenges in a short speech and small group discussions with local experts.
- Connect with other student leaders from across Michigan to share ideas, identify solutions to these problems and build lasting friendships.
- Interact with global leaders in science, agriculture, industry and policy.
- Take part in educational sessions and interactive panels at MSU to explore current research and issues in international development and life sciences.
- Meet innovative researchers, professors and college students in Michigan working to end hunger and poverty and improve food security around the world.
- Discover how to be actively involved in influencing global change.
- Increase youths' communication, teamwork, citizenship, and leadership skills.
- Foster participants' ability to meet new people and make new friends from different places and backgrounds.
- Develop and expand career and personal interests.
- Develop social and academic skills needed for a successful transition to college and life as an adult.

Description:
Youth development and experiential education theory and practice are fundamental to the program's design and implementation. This pre-college program is a one-day event held on campus where high school youth present research and recommendations on how to solve key global challenges, connect with other student leaders from across Michigan, interact with global leaders in science, agriculture, industry and policy, meet innovative people working to improve food security around the world and more! Through personal research and public presentation, on-campus immersion visits, faculty question and answer panel, and discussions with MSU department representatives, youth participants are given the opportunity to engage with global food security and food access at many levels. Another key component of World Food Prize Michigan Youth Institute is roundtable dialogues between youth participants, faculty and community experts. The papers that youth participants write and submit in advance of the event determine the content for these roundtable discussions. At the event, youth give short presentations in their roundtable groups, highlighting their research on a specific country and a food security factor, as well as their recommendations for solving regional challenges. Participants' evaluations show that World Food Prize Michigan Youth Institute, on its own, is a very engaging and powerful experience.
Michigan State University Extension (MSU Extension), Michigan 4-H,Michigan FFA and the MSU College of Agriculture and Natural Resources, along with the World Food Prize, make up the team of partners that make the World Food Prize Michigan Youth Institute possible. This free event is offered free of cost to all participants, youth and mentor-like adults alike. In 2016 there were 6 MSU faculty serving as MSU Extension Educators or Administration, 2 former MSU Extension staff members (now retired), 5 former Michigan Youth Institute youth experts, over 15 MSU teaching faculty and/or graduate student experts, 5 community based experts, and countless other MSU staff who volunteered their time to make this event possible.

Outcomes
A pre-/post-survey was used to measure participants skills and perceptions. Below are response highlights for youth who "strongly agreed" with targeted skills. Before the event responses are shown in parentheses.

- I can apply knowledge in ways that solve problems. - (34%) 70%
- I understand that other ideas are just as important as my own. - (35%) 83%
- I know how to set goals and I use them when I am leading a group. - (48%) 74%
- I recognize the importance of different viewpoints when making decisions. - (52%) 83%
- I think it is important to listen to all group members before making a decision. - (57%) 87%
- I am comfortable sharing my thoughts and feelings with others. - (35%) 70%
- I have confidence speaking in front of groups. - (39%) 65%
- I can make a difference in my community. - (30%) 74%
- I feel prepared to work toward change in my community. - (22%) 65%
- I plan to work on projects to better my community. - (30%) 61%
- I have skills to help me serve my community. - (22%) 57%
- I learned things that will help me make a difference in my community. - (23%) 65%
- I can contact someone I've never met before to get their help with a problem. - (23%) 57%

Key Items of Evaluation

Adults reached in this area by MSUE Institute Work Teams

Institute for Agriculture and Agribusiness

1,776 AABI-02. Business Management
10,659 AABI-03-Consumer Horticulture
8,417 AABI-04-Field Crops
3,484 AABI-05-Fruit
1,843 AABI-06-Ornamental Horticulture
1,785 AABI-07-Vegetable

Institute for Greening Michigan

6,594 GM-1. Community Food Systems
3,547 GM-2. Natural Resources Stewardship

Institute for Health and Nutrition

6,456 HN-2. Food Safety

AgBioResearch Key Items:

DEVELOPING BIOBASED PRODUCTION SYSTEMS FOR COMMERCIAL APPLICATION

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 bio- processes and technology from the lab to the marketplace.

She explained that finding long-term food and energy sources, as well as solving other production challenges, is a big problem that could be answered in part by something very small -- microbes. "My research focuses on bridging the gap between process operation and system engineering," Liu said. "Microbes have enormous genetic capabilities and represent endless possibilities to sustainably produce some of the most essential elements of our human existence.
For more information, http://agbioresearch.msu.edu/news/publications/annual_report

Kyrgyzstan: Building capacity for a sustainable agriculture industry
Christmas Day, 1991. Kyrgyzstan achieved full independence, ending an era of Soviet rule stretching back to the end of World War I. Those living in the mountainous nation in Central Asia suddenly found themselves governed by elected officials in their own capital of Bishkek. While the change brought freedom, it also brought challenges; among them, food and agriculture. Suddenly, the newly reborn country found itself responsible for its own institutional infrastructure, something previously under tight Soviet control. This was only complicated by the political, cultural and linguistic isolation that was inherited from the previous government. Up until then, contact with Western scientists and resources had been deemed a national security threat, and access to English-language materials, which made up the bulk of agriculture research, was heavily restricted.

As a result, Kyrgyz farmers had been left without access to the latest advancements - in particular, pest management methods and technologies. They continued to rely heavily on chemicals for disease and insect control, which eventually contaminated the soil and water. Murat Aitmatov, a professor at Kyrgyz National Agrarian University (KNAU) in Bishkek and director of its Center for Bio-Cultural Diversity, was all too familiar with the challenges confronting his homeland.

"After the Soviet Union collapsed, many people who had never farmed before suddenly found themselves having to do so," Aitmatov recalled. "They were teachers, veterinarians, doctors. They didn't have enough information or training in agriculture, so they ended up using a lot of chemicals."

The need for new, innovative solutions for Kyrgyzstan's food and agriculture industry was clear, and it nabbed the attention of researchers at Michigan State University (MSU).
NEW PARTNERS, NEW OPPORTUNITIES
Kyrgyzstan did not stand alone for long. In the wake of the Soviet collapse, the International Center for Agricultural Research in Dry Areas(ICARDA), a nonprofit international agricultural development organization operating across Africa and Asia, established a regional office to facilitate the development of the fledgling agricultural sector. MSU was among ICARDA's partners at the time, the only land-grant university from the United States to join the organization's consortium for Central Asia and the Caucasus.

Karim Maredia, MSU professor in the Department of Entomology and program director for the World Technology Access Program, said the agricultural challenges facing Kyrgyzstan quickly became apparent. In 2005, he was awarded a small planning grant from the Feed the Future Innovation Lab for Integrated Pest Management (IPM) at Virginia Technological University, funded by the U.S. Agency for International Development (USAID), to explore a collaborative, multi-institutional effort to connect the countries of Central Asia with the global IPM community and improve agricultural capacity.

"The countries we traveled to had limited resources to dedicate to agriculture, and they had very little capacity for research or an extension system," Maredia said. "All the earlier work was done by non-governmentalorganizations, which came and went for different projects but rarely stayed.We wanted to build their capacity for a sustainable agriculture industry, to help them be able to help themselves and secure long-term food security solutions."

During the first year, Maredia and a team of faculty members from MSU and the University of California, Davis, traveled to Kyrgyzstan and two of its neighboring nations - Uzbekistan and Tajikistan - to assess the situation and determine where efforts would best be spent. They identified wheat, potatoes and tomatoes as the crops with the highest food security significance. Then they hired a research fellow from each of the countries to implement the new programs in the field. The team chose Aitmatov to be the Kyrgyzstan rep.
For more information:
http://agbioresearch.msu.edu/news/kyrgyzstan_building_capacity_for_a_sustainable_agriculture_ind

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: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	14.8	0.0	9.5	0.0
Actual Paid	13.0	0.0	10.0	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**
571842	0	898837	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
571842	0	884648	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	4783296	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?

An example of an activity in this area is:
Dairy Community of Practice
Dairy Community of Practice offers a series of webinars related to a broad range of dairy management issues. he target audiences are extension educators, dairy producers and dairy farm employees, and agribusiness professionals. One example in this areas was the presentation "Optimizing production by managing how dairy cows eat". The listings of archived webinars and planned webinars can be accessed at: www.extension.org/dairy+cattle

Another activity was:
Horse Quest
MSUE staff member chaired Social Media committee for this Community of Practice.
Results was increased engagement in using social media platforms:
YouTube: www.youtube.com/exhorses, reached over 5 million video views in 2016
Facebook: https://www.facebook.com/eXtensionHorseQuest/?fref=ts, over 6,000 page likes in 2016
Twitter: https://twitter.com/eXtensionHorses, in 2016 after a concerted effort to increase participation in 2016 the decision was made to refocus efforts away from Twitter as it was less successful than YouTube or Facebook for our followers.

Another activity included:
Organized 4-H Horse Events: Biosecurity
This group focused on biosecurity issues where organized 4-H horse activities are a large part of local 4-H extension programs. These activities range from horses shows, including county fair horse shows, and open shows sponsored by local clubs as practice shows and fundraisers, as well as riding meetings, trail rides, parades and other local activities. The commingling of horses at these events creates an increased chance of the spread of disease, both to the horses at the event, and animals remaining at home. County extension staff, with widely varying experience with horses, or large animals, may be asked to intervene to support the volunteers when making difficult decisions about if horses should be allowed to participate due to health reasons. Tools that would increase the educator self-efficacy in making these decisions, and increasing their credibility with the clientele in this area, would increase the effectiveness of local educators and volunteers to properly manage health issues and to promote sound biosecurity at organized 4-H horse events. This CoP focused on this need to increase understanding by 4-H families of the importance of biosecurity, resulting in fewer sick horses coming to horse shows and other organized events with horses.

Another example,
Presented at the National eXtension Conference in San Antonio, "When Birds Made Us Batty: A case study in managming tough issues across multiple audiences."
"After all state poultry shows and exhibitions were cancelled by the Michigan Department of Agriculture and Rural Development, Michigan State University Extension communicators and educators worked with industry and regulatory partners to develop a comprehensive plan to address the ban's implications on 4-H while maintaining consumer confidence in poultry products. The presentation described working with key partners involved in planning and disseminating in developing a strategic plan that put 4-H'ers on the front lines of keeping this devastating disease out of Michigan. The presentation described how the word got out to youth and adult audiences, via more than 30 media outlets, 20,000 social media views and 14,500 website visits, created viable alternatives to live poultry shows and increased participation in county fair poultry events. The team evaluated the situation from the public perception, and the tools they used-- FAQ's for the general public, talking points for staff to use with 4-H families, and a poster for the general public -- to ensure there was no panic when people saw empty poultry barns at fairs."

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	4214	12642	100470	301410

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

Patent Applications Submitted

Year:	2016
Actual:	2

Patents listed
MICL02127, Generation of Bovine Pluripotent Stem Cells Using Fertilization, Somatic Cell Nuclear Transfer, and Transcription Factors, Serial numbers 62/024,279, 62/064,227

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	2	38	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research programs on animal production and protection.

Year	Actual
2016	38

Output #2

Output Measure

- Number of adult participants trained in animal management systems.

Year	Actual
2016	4214

Output #3

Output Measure

- Number of youth participants trained in animal management systems.

Year	Actual
2016	100470

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
2016	3793

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example in this area is the new Veterinary Feed Directive (VFD) rules impact all food production animal producers. These rules seek to ensure that antibiotics used in animals, that are also used in humans (termed "medically important"), are used in a judicious way. The rule applies to medicated feed (requiring a VFD), and medications used in water (requiring a prescription).

What has been done
Seven meetings were conducted by the MSU Extension Dairy Team members across Michigan to address this need. The host sites were Fremont, Cadillac, Ionia, Ellsworth, Lachine, Clare, and Sandusky. Area veterinarians, feed mill representatives, and drug company representatives were also involved.

Attendees learned:

What is the Veterinary Feed Directive (VFD)

-How the VFD will affect feed-delivered antibiotics commonly used in agriculture

-How your farm can comply with the VFD

-What is a Veterinary-Client-Patient Relationship (VCPR)

-What you need to do to obtain feed-based antibiotics

Discussion on implementation of VFD with veterinarians and nutritionists

Results
Results found:

124 people attended the program in the seven locations offered.

A total of 97 individuals filled out the survey at the end of each meeting.

Over 85% of respondents indicated that they had "high" increase in their knowledge (4 or 5 on a scale of 1 to 5) in the areas of "Key changes in FDA antimicrobial drug regulations" and "Procedure for obtaining and following a VFD order". Over 74% of respondents indicated that they had a "high" increase in knowledge about "Drugs considered as medically important" and "Types of questions asked during producer on-farm audits".

66% of respondents indicated that they planned to make management or facility changes to increase their focus on disease prevention as a result of the meetings.

27 participants responding with a total of over 12,000 dairy cows

19 participants responding with a total of over 2,000 beef cows

25 participants responding with a total of over 6,000 beef

31 Industry professionals responding that they served a total of over 5,000 farms

What difference did it make - public value?

This program focused on new FDA rules impacting food animal producers. Antibiotic resistance is a growing problem, and the rules focus on antibiotics that are used in both humans and animals. With judicious use of these drugs by farmers, doctors, and patients, we can slow the development of resistant bacteria and keep important antibiotics available for future use. Producers that attended these meetings indicated that they planned to make changes that focus on prevention, thus reducing the need for antibiotic treatments.

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
2016	88414

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example in this area is 4-H youth enrolled in Animal Science projects in St. Joseph County are required to attend one educational meeting during the winter. The program was open to all 4-H youth enrolled in St. Joseph and neighboring counties.

What has been done
To address this need, MSUE conducted the St. Joseph Co. Dairy Livestock Meeting. This interactive session lasted for 60 minutes and included time for discussion and interaction with participating youth and adults. The objectives of the session were:

-Introduce youth to the concepts of animal well-being.
-Discuss how these topics are important for every day care of dairy animals.
-Explore special considerations for dairy cattle at fairs and expos, such as heat stress, food water availability, and biosecurity.

Results
Impacts
As a result of this presentation:

88% of youth indicated an interest and engagement in science.
76% of youth indicated positive attitudes and aspirations towards science.
100% of youth indicated they are aware of science skills learned in 4-H programming.
100% of youth said they could identify science skills they were learning in 4-H.

Participant Demographics
23 participants voluntarily completed the application.

56% female, 44% male
96% identified as Caucasian/White, 4% did not answer.

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
2016	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Unless you are a strict vegetarian or lactose intolerant, chances are that dairy and beef products make up half of your diet. According to the U.S. Department of Agriculture, almost 40 percent of the average American diet is dairy, and beef makes up 10 percent. This makes these products an integral part of our lifestyle and our economy, this sustained productivity and animal health are critical issues to the cattle industry.

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

In the short period since we started this proposal, we have already determined the efficiency of SCNT for four different zebrafish transgenic lines, we have performed RNAseq studies in single unfertilized metaphase II oocytes, and single fertilized and SCNT embryos at the time of genome zygote activation. We are in the process of generating a transgenic zebrafish model that will demostrate our capacity to control gene expression of a give gene in the oocyte before it reaches metaphase II.

Implementation of GWA and genomic predictions for economically important traits in pig production. We published GWA and meta-analysis GWA on meat quality and growth traits in pigs and discovered new candidate genes and regions controling those traits. And we are starting to use it for analysis of behavioral traits. 2. Developing methods and tools for genetical genomics research. Our tools have been tested under a number of datasets, HMMASE is being expanded to include modeling of phenotypes. gwaR has been expanded to perform meta analyses and a multivariate version is under construction. 3. Application of genetic analysis of transcriptional and phenotypic variation to uncover causal genes. We presented results of the first application of this package in the joint ASAS-ADSA meeting. Package is now being used to perform GWA and EWA.

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
2016	2

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.

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

The MSU pig resource population was established from 4 F0 Duroc sires and 15 F0 Pietrain dams and produced approximately 950 F2 offspring. This population has been used extensively for identification of quantitative trait loci (QTL)influencing growth, carcass composition and meat quality traits, as well as expression QTL (eQTL) for loin muscle tissue to identify potential candidate genes. Previous studies utilized microsatellite markers, and continuation of this work involves analysis of single nucleotide polymorphism (SNP) marker genotypes for the population using a combination of high density (60K, Illumina SNP60 BeadChip) and low density (8.5K, GeneSeek Genomic Profiler for Porcine LD) panels. The F0, F1 and approximately 1/3 of the F2s were genotyped with the 60K panel, while the remaining F2s were genotyped with the low density panel. Imputation of all F2 SNP genotypes was completed in collaboration with MSU colleagues, and SNP genotypes have been used for genome-wide association studies for growth, carcass composition, and meat quality phenotypes. RNAseq technology has been used to obtain transcriptome sequences for 168 longissimus muscle samples from the resource population in order to refine the eQTL analysis for the population. Analysis of this data has revealed novel coding SNPs,
including SNPs exhibiting allele-specific expression bias. Sequencing of small RNAs has also been completed for 174 F2 longissimus muscle samples in order to reveal microRNA regulation of gene expression, resulting in identification of 295 mature miRNA expression profiles. An eQTL analysis was performed with the miRNA profiles revealing 26 significant eQTL
associated with 18 miRNAs. In addition to eQTL analyses, evaluations have been extended to development of methods for analysis of RNA editing sites. Whole genome sequence along with transciptome sequence for three tissues was obtained for a single pig, revealing over 8500 putatively edited sites including those exhibiting tissue specificity. Of these 8500 sites, 75% exhibited a canonical A-to-G edit expected for modifications catalyzed by the enzyme adenosine deaminase acting on RNA
(ADAR) . In addition, the majority of A-to-G mismatches were located within repetitive sequences, with most of these occuring in the PRE-1 retrotransposon.

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
2016	8

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). 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
New strategies were designed to reduce abundance of antimicrobial resistant bacteria on dairy cattle.

Wee have sequenced the entire genome of EHV 5 isolates associated with the development of EMPF as well as the genome of non-pathogenic EHV 5. The large amount of data generated is currently being evaluated by colleagues at Wayne State University. We anticipate that the data derived from this work will provide important insights into virus-specific determinants of disease in the pathogenic isolates of EHV 5.

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
2016	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Livestock production has been recently characterized by the assertion that production systems are changing more rapidly than animal populations can adjust by natural selection. Future changes would appear to be only just as dramatic, given emerging issues such as those, for example, driven by climate change and biofuel energy policies. Hence, it seems vitally important that the germplasm pool for all current and potentially economically important livestock species be sufficiently diverse to accommodate these and other unforeseen changes. Heterogeneities of effects on the responses of interest (like milk or meat production) exist on many different scales, beginning at the gene, then the animal, finally the environment level, and intersect with heterogeneities potentially existing at several other levels (e.g., different times or developmental stages). Quantitative genetic evaluation systems that facilitate the proper assessment of these phenomena should be developed in order to ensure that genetic diversity of livestock in the United States sufficiently great and fluid to optimize production of animal products across a wide range of environments and management conditions.

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
Co-edited a special issue on "Statistical Genomics and Transcriptomics in Agriculture" in the December, 2015 issue of the Journal of Agricultural, Biological, and Environmental Statistics which further highlights our review paper outlining the statistical and computational challenges that we are partly attempting to address, hoping to further engage the broader agricultural statistics community beyond animal and plant breeding.. To sidestep some of these computational burdens, many breeders often pay inadequate attention to carefully tuning these models, particularly those based on flexible Bayesian specifications and using computationally intensive Markov chain Monte Carlo (MCMC) techniques. In that same special issue, we have developed a computationally efficient alternatives to MCMC, adapting expectation maximization (EM) algorithm, for providing GS inference based on flexible hierarchical Bayesian specifications along the additional benefit that we extend EM to estimate tuning parameters, an issue which has not been adequately addressed in previous EM WGP implementations.

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
2016	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Due to improvements in nutrition, management and health care, horses are living longer, more useful lives. It's not uncommon to find horses and ponies living well into their 20s and 30s. Although genetics play a determining role in longevity, providing proper care and nutrition plays a key role in horses' health, performance and overall well-being.

What has been done
Research to: Understanding how the small blood vessels in the lung of EIPH-affected Thoroughbred racehorses work, and how they are affected by racing for fully effective prevention and/or treatment strategies; exploration into one increasingly popular equine dietary supplement (omega-3 fatty acids) that has been linked to skeletal health and also whether horses are susceptible to a health concern (?Leaky Gut Syndrome?) that afflicts humans and could have detrimental effects in horses.

Results
Regional differences in large equine pulmonary artery reactivity exist. It is not known if this heterogeneity extends into small vessels. The hypothesis that there is regional heterogeneity in small pulmonary artery and vein reactivity to sympathomimetics (phenylephrine and isoproterenol) and a parasympathomimetic (methacholine) was tested using wire myography on small vessels from caudodorsal (CD) and cranioventral (CV) lung of 12 horses [9 mares, 3 geldings, 8.67 ± 0.81 (age ± SE) yr, of various breeds that had never raced]. Our data demonstrate significant regional heterogeneity in small blood vessel reactivity when comparing the CD to the CV region of the equine lung

Research from our laboratory has confirmed only moderate possible anti-inflammatory benefits from orally supplementing omega-3 fatty acids, despite widespread belief that such supplementation can decrease lameness in performance horses. Based on a cost to benefit ratio, our research does not support the use of such supplementation in most horses but can likely justify the use of such when cost is not a factor in the case that it might have a small benefit. Beyond that, these studies have lead to other work that have investigated ways to reduce lameness in performance horses such as through the use of a vibrating platform which is a treatment commonly used in the horse industry. Our research showed no benefit from such 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
2016	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
We have continued outreach efforts to promote better stewardship of antibiotic use on dairy farms. Mastitis is the single most common cause of antibiotic use in adult dairy cattle. Thus, we have focused on reducing unwarranted use of antibiotic therapy for the treatment of this disease. Key contributions included workshops on mastitis therapy and employee education for dairy producers and veterinary practitioners to help these stakeholders make better therapeutic

decisions. Additionally, several presentations were given to veterinary practitioner and dairy producer groups to highlight the interaction between poor therapeutic decisions and residues in meat and milk.

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
2016	10

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 published our research showing that the metabolic and physiologic effects of organic and inorganic Zn are different.

This is an important finding in swine nutrition, and has stimulated additional work by many researchers around the world. Use of pharmacological doses of phytase (superdosing) with differing genetics and management, but only one form of phytase, does not appear to be useful to producers. However, this work needs to be duplicated with other commercially available phytase including its effect on zinc.

To meet the needs of swine producers because of the devastating effects of PEDv, we investigated the purported effect of vitamin E on farrowing time. This work resulted in two winning awards for undergraduate researchers. Currently, the findings of this research is the basis of a large scale investigation in a commercial herd in North Carolina.

We analyzed digestibility data from 662 cows in 56 studies from 3 universities and developed new equations to predict digestibility of dry matter, starch, and fiber based on diet characteristics and feed intake. Our results confirmed that digestibility was reduced as feed intake increased, but at a lower rate than in most previous equations. Digestibility of dry matter and starch could be predicted based on only feed intake, but digestibility of fiber required diet characteristics. Increasing starch content and increasing feed intake both decreased fiber digestibility.

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 2015-16 fiscal year, ABR and MSUE were able to 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 600 in 2015. Project GREEEN funds supported operational upgrades including strategic network and system modernization, as well as routine weather network maintenance. Sixteen Enviro-weather stations were upgraded with new loggers and sensors in 2015-16. Two new stations were added to the Enviro-weather network: Deerfield in September 2015 and Elbridge/Hart in May 2016.

Project GREEEN funds are used by the Land Management Office to help keep MSU AgBioResearch centers operating at full capacity. Funds are often used for new equipment and skilled labor positions. Many research centers were able to provide maintenance and repair services to infrastructure in 2015-16 through Project GREEEN, as well as funding for field trials, pest management and more. Numerous research center projects also benefited from Project GREEEN dollars, including:

- Monitoring for invasive grape pests.
- Sweet cherry bacterial canker research.
- Spotted wing drosophila monitoring in fruit crops.
- Trevor Nichols Research Center field lab renovations.
- Clarksville Research Center asphalt replacement and repair.

Together, MSUE and ABR continue to serve as the primary research and development arm for the agriculture and food industries in Michigan, valued at more than $100 billion annually.

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 MSUE evaluation results include:

MCA/MSU Bull Evaluation Program (BEP)

Issue (who cares and why)?

This program directly impact the health and economic viability of beef industry in Michigan.

What has been done?

Survey data from buyers and consignors was compiled over the past three years including economic impact data based on current market conditions.

Results/Impact?

Key impacts include:

1. $1,468,000 in added value form this program directly impacting the beef industry.
2. Testing data and procedures from the BEP provide $940/bull sold in added value netting $65,800 per year.
3. Buyers estimate this program saves them $516/bull purchased by having this program

locally. This saves the industry $36,105 each year by keeping dollars in Michigan.

What difference did it make - public value?

This program continues to offer a strong collaborative partnership with Michigan State University and the Cattle Industry in Michigan and surrounding states.

Another example,

2016 Great Lakes Forage & Grazing Conference

Background:

The Michigan Forage Council and MSU Extension partner to provide an educational conference for forage and grazing clientele. This is a critical program for the forage based farm industries of Michigan. The event took place at the MSU Kellogg Center on March 10, 2016.

Forages for livestock feed include alfalfa, grass, corn silage, and pastures. In 2015, Michigan had 970,000 acres for hay, 41,097 acres for pasture, and 260,000 acres for corn silage totaling 1,271,097. Forages are the third largest commodity crop in Michigan after corn and soybeans and represented $417,570,000 in revenue for farmers in 2015. Forages are also an integral part of the dairy, beef, horse, sheep and other small ruminant industries in Michigan.

Demographics:

102 producers attended this conference from 45 different counties from Michigan, Indiana, and Ohio. A post-meeting evaluation was circulated to the attendees and 36% (n=37) were returned and summarized.

Of those that submitted the evaluations:

- 73% were farmers (n=27)
- 5% were government/education (n=2)
- 5% were agribusiness (n=2)
- 3% were students
- 3% were consultants
- 16% were other (n=6)

7,058 acres of forages were grown by the respondents. The types and acres were:

- 2,223 alfalfa (n=16)
- 412 corn silage (n=7)
- 1,116 grass (n=18)
- 21 pasture (n=21)
- 3,166 alfalfa/grass mix (n=24)
- 120 annual forages

2,580 head of livestock were owned or directly managed by those responding to the survey. The types and species were:

- 684 dairy (n=3)
- 171 goats (n=7)
- 651 beef - cow/calf (n=20)
- 10 horse (n=4)
- 178 beef feedlot (n=7)
- 484 sheep (n=5)
- 70 finishing young stock
- 300 dairy heifers

Outcomes:

The conference theme, "Forages for the Future", had 10 separate educational sessions during the day. The sessions provided forage producers, graziers, and agribusinesses the

opportunity to learn new information that could help them adopt new practices and technology for improving production efficiency.

- 97% (n=35) of respondents indicated a moderate to great improvement of knowledge-attitudes-or skills as a result of the information presented at the conference
- 54% (n=20) responded that they would be consider adding a sulfur source when managing alfalfa fertility for greater profitability.
- 70% (n=27) indicated they would make management changes as a result of the information presented at the conference
    - Improve soil fertility practices (n=9)
    - Adjust pasture mix practices (n=2)
    - Change alfalfa management (n=13)
    - Change grazing management (n=3)
- Those that responded to the above change for management said that the number of acres affected would be 2,260 acres:
    - 578 (n=7) grass/alfalfa
    - 617 (n=7) alfalfa
    - 75 (n=1) hay/pasture
    - 100 (n=1) grass
    - 70 (n=1) sorghum
    - 432 (n=3) hay
    - 318 (n=5) pasture
    - 70 (n=2) cover crops
- Those that responded to the above change for management said they anticipate the changes to affect 1,704 head of livestock (n=25):
    - 187 (n=3) sheep
    - 967 (n=20) cattle
    - 550 (n=2) dairy

Respondents were asked to estimate the dollar value of increased revenue or savings the management changes would mean to their operation in the future:
On the cropping enterprises, respondents indicated there would be a total of $21,835 (n=15) of increased revenue or savings as a result of the education provided during the conference.
On the livestock enterprises, respondents indicated there would be a total of $24,710 (n=10) of increased revenue or savings as a result of the education provided during the conference.

Another example,

Michigan 4-H Dairy Conference March 11-13, 2016

Audience

This workshop is open to youth (aged 11 and older) and adult leaders interested in dairy science, management, and judging. 76 total participants attended - 32 males and 44 females representing 11 counties. 60 youth participated along with 16 adults. This represented a 8.5% increase in attendance from the 2015 event.

Funding

Sponsorship made the event possible with funding from The American Dairy Association of Michigan, and the Michigan Milk Producers Association. There was also a $75.00 participant fee for 4-H members and leaders.

Objectives

This conference is designed to:

- 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.

Description

Participants had 15 contact hours with 2 dairy industry professionals, 1 MSUE Educator, 2 MSU faculty from the Department of Animal Science and the College of Veterinary Medicine, 3 local dairy farmers, and 2 large animal veterinarians.

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: dairy calf anatomy and physiology; feeds identification; dairy cow nutritional diseases case studies; rumen anatomy; how to formulate a ration; dairy judging; a farm tour and activities; and dairy quiz bowl.

Impacts

- 47 (78% of participants) youth voluntarily submitted a retrospective post-then-pre evaluation of their experience at the conference.

- 87% of respondents indicated an interest and engagement in science after the conference comparted to 86% before the conference.

- 75% of youth indicated positive attitudes and aspirations towards science after the conference compared to 72% before the conference.

- 85% of youth demonstrated a capacity for science process skills after the conference compared to 78% before the conference.

- 97% of youth indicated they were aware of the science skills learned in 4-H after the conference compared to 80% before the conference.

- 91% of youth could identify the science learned in 4-H after the conference compared to 78% before the conference.

- 89% 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 87% before the conference.

- 93% of youth indicted they were aware of the life skills learned in 4-H after the conference compared to 84% before the conference.

- 91% of youth could identify life skills learned in 4-H after the conference compared to 78% before the conference.

- 88% of youth were felt more knowledgeable about entrepreneurship and career opportunities in science-related fields compared to 78% before the conference.

Another example,

2016 Michigan 4-H Ag Innovators Experience Grant

Funding

Michigan 4-H received an $20000 grant in 2016 to implement the 4-H Ag Innovators Experience project in a variety of settings in counties across the state of Michigan. The

grant is funded through National 4-H Council and sponsored by Monsanto. Michigan was 1 of 8 states to participate in the project in 2016; making this the third year Michigan has been selected to receive funding for this project.

Audience

Michigan 4-H was able to engage over 1750 youth in the Honey Bee Challenge activity. The activity was delivered to participants in 16 counties through 45 event sites/locations. Program delivery models included: in school, after school, summer school, 4-H club meetings, 4-H day and overnight camps. The activity was primarily led by trained teen leaders with support from project coordinator and local 4-H staff. A total of 24 teen leaders were trained to lead the activity.

Description

The 4-H Ag Innovators Experience project utilizes a science and engineering activity each year to increase youth engagement in science exploration. The activity makes a connection between science and careers in the agriculture industry with science applications; helping youth see a career path in the agriculture field even if they are not from a farm background. The 2016 activity was the 4-H Honey Bee Challenge. Participants worked in small groups to build a model bee using a bristle-bot kit; the robotic bees were then used to simulate pollen collection on a map. In addition to science and engineering skills, youth working in groups used communication, cooperation, and teamwork to accomplish their tasks. Another aspect of the education provided with the activity was to provide awareness to participants that food production is greatly influenced by bees. There is also conversation around the growing world population and the potential affects this change will have on food availability worldwide.

Local 4-H Ag Innovators Experience events are largely taught by teen leaders who are trained to facilitate the activity. A total of 24 teen leaders received training; 14 attended the statewide training at Kettunen Center during the Teens as Teachers Workshop. The remaining teens were provided training during other local events. Through the experience, teen leaders gain a tremendous level of confidence in their facilitation and communication skills. Teens also increase their organization and leadership skills.

Michigan had a great year with the 4-H Ag Innovators Experience! The Honey Bee Challenge was well received and wildly popular. Additional orders for kits were submitted twice in order to meet the demand for the activity. Program events took place March-July; with additional event requests scheduled beyond the grant delivery period into October. The honey bee theme was especially timely as the increased concern over honey bee populations decline.

In order to extend the impact of the activity beyond the event, each participant was provided materials to take home: honey stick, package of wildflower seeds, and two "Ag Mags" purchased through American Farm Bureau Foundation--Bees and Ag Careers. These items were packed into the backpacks provided by the sponsor and provided an opportunity for the youth to share with their parents.

Impact

Youth participants in the Honey Bee Challenge activity completed a 5 question survey to gage their feelings about the activity. A total of 958 surveys were collected; with 930 completed. The survey questions asked of the youth participants were:

1. Did you think it was important to work in a group to accomplish the task during the Honey Bee Challenge? 74% yes; 20% kind of; 6% no
2. I had to use communication skills with my team in order to accomplish the Honey Bee Challenge? 67% yes; 24% kind of; 8% no
3. I think honey bees are a good way to increase food production for our world to have

more food? 89% yes; 9% kind of; 2% no

4. I am more interested in science and agriculture after participatin in the Honey Bee Challenge? 46% yes; 35 kind of; 19% no

5. I have a better understanding of how to design and create an object to solve a problem after participating in the Honey Bee Challenge? 63% yes; 28% kind of; 9% no

Another example,

Bovine Leukosis Virus (BLV) Project

Issue:

Bovine Leukosis Virus (BLV) is an incurable, not treatable, disease of cattle that suppresses the immune system, reduces milk production in cattle 3 years of age and older, and reduces the life of positive cows in the herd compared to their negative herdmates.

What has been done:

43 herds were recruited to be a part of the 2105 BLV Project in which these herds had an initial Herd Profile test to determine the herd prevalence by lactation. Each then had a call or a visit to discuss their results and actions that could be taken to reduce the risk of transmission. Each herd was scheduled for a second Herd Profile test aproximately one year after the first. A survey was sent (email and surface mail) to each herd owner to determine the changes they made in management in several key areas that impact the tranmission of the virus.

Results/Impact:

41 herds were still operating one year later and are still being tested. From 39 (95%) of the herd owners, the survey was completed and received. For the two for which it was not yet, we know by phone conversation and farm visit about practice changes.

The results are outstanding:

88% of these farms changed some managmeent practices that impact BLV transmission, some very significantly.

Of those that made changes:

- 22 (61%) either switched to single use of needles or started changing needles more frequently.
- 21 (58%) either switched to single use of exam sleeves or started changing sleeves between groups.
- 7 began freezing colostrum
- 3 made improvements in their fly control
- 3 culled positive animals

What difference did it make - public value:

The control of disease in animals used for food production is always important. In addition, the control of disease that increases the death of animals and reduces their productibity is an animal well-being issue.

Key Items of Evaluation

MSUE Institute Work Team Outputs in this area:

Institute for Agriculture and Agribusiness

4,214 AABI-01-Animal

1,776 AABI-02. Business Management

16,280 Public Event, Breakfast on the Farm, Ag Literacy, Consumer Ed, etc.

Institute for Children and Youth*

552 Career Education/Work Force Preparation

1,390 Leadership & Civic Engagement

Institute for Greening Michigan

6,594 GM-1. Community Food Systems

2,505 GM-3. Government and Public Policy
423 GM-4. Entrepreneurship
509 GM-7-Leadership and Community Engagement (LCE)

Institute for Health and Nutrition

6,456 HN-2. Food Safety

AgBioResearch Key Items:

IMPROVING GENETIC SELECTION MAY HOLD KEY TO PEACEFUL PIG GROUPING

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."

Pigs naturally live in small groups that consist of their mothers and other close relatives. There is a social hierarchy within these groups, which normally works to reduce aggression and fights because they know the social order. When unrelated pigs are mixed in
a shared space, fighting can become intense.

"Unfamiliar pigs oftentimes fight like the dickens when they are put in the same pen," Siegford said. "This becomes problematic for a number of reasons. Obviously, the animals' welfare is adversely affected. And injured or stressed pigs don't perform as well, and they can even die from exhaustion or heat stress."

Breeding programs have traditionally focused on production traits and other relatively easy-to-measure physical characteristics, such as number of offspring, growth rate and depth of back fat. Though it's sometimes difficult to quantify, Siegford said that behavior should also be taken into consideration.

For more information: http://agbioresearch.msu.edu/news/publications/annual_report

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%		19%	
402	Engineering Systems and Equipment	0%		8%	
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%		7%	
504	Home and Commercial Food Service	0%		14%	
511	New and Improved Non-Food Products and Processes	50%		12%	
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins	50%		16%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	5.2	0.0	6.0	0.0
Actual Paid	3.0	0.0	8.0	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**
112390	0	599225	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
112390	0	589766	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	3188864	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?

Two examples in this area regarding food safety were:

- Addressing the food safety issue of lead that may leach from a fire arm when used to kill potential food such as venison.
- Developing and updating On-Line food preservation courses.

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	6604	19812	0	0

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

Patent Applications Submitted

Year:	2016
Actual:	1

Patents listed

MICL02007, Field-Operable Nano-Biosensors for Global Health, Biodefense, Food Safety, and Water Quality, Serial number 14/400,996

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	0	28	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
2016	21

Output #2

Output Measure

- Number of adults trained on new and improved non-food and bioeconomy related products and processes.

Year	Actual
2016	148

Output #3

Output Measure

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

Year	Actual
2016	6456

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
2016	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; rovide 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
Cheddar cheese was manufactured using standard Cheddar cheese procedures a total of three times. Cheddar cheese was fortified with LMFS (Large Micro-Encapsulated Ferrous sulfate, 700-1000 μm) or Small Micro-Encapsulated ferrous sulfate, 220-422 μm). After 90 d aging, mineral content was analyzed using Atomic Absorption Spectroscopy (AAS). In order to provide further information, lipid oxidation assessment, sensory evaluation, and proximate analysis were performed. All
collected data was analyzed using one-way ANOVA and Tukey's HSD Test ($p = 0.05$). Iron content for all treatments were significantly different ($p<0.05$); approximately 0.030 mg Fe/ g cheese for the control, 0.134 mg Fe/ g cheese for LMFS, and 0.174 mg Fe/ g cheese for SMFS.

Results showed 66.0% iron recovery for LMFS and 91.0% iron recovery for SMFS. Fat, protein, ash, moisture, magnesium, zinc and calcium content were not significantly different when comparing fortified cheeses with the control. No lipid oxidation changes due to fortification were reported in the iron fortified Cheddar cheese. Consumer acceptance testing demonstrated that iron fortification negatively affected Cheddar cheese sensory attributes. Micro- encapsulation of ferrous sulfate failed to mask iron distinct taste, color and odors. Overall, micro-encapsulated ferrous sulfate caused no major changes in composition and successfully increased iron content in Cheddar. SMFS showed slightly better
results for iron retention and sensory evaluation in Cheddar cheese. This study provides new information on fortification, size particle and micro-encapsulation research. In the future, it is recommended to select a lower fortification dose for SMFS to analyze possible sensory evaluation benefits.

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
2016	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
We compared the effects of sex and age on trichothecene- induced anorexia and vomiting. We identified further molecular targets of deoxynivalenol in an enteroedocrine cell model. We further demonstrated that 8-ketotrichothecenes 15- acetyldeoxynivalenol, -acetyldeoxynivalenol, fusarenon X, and nivalenol induce anorexia and vomiting by similar mechanisms as DON.

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
2016	7

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
We screened several biological sources of natural products and identified several which block Aspergillus growth, sporulation, spore germination, and/or mycotoxin biosynthesis. These pure compounds are being scaled up for field tests and safety testing in animal models.

n the last few years, our lab has been working on wheat starch adherent to bran (bran starch), the characterization of this bran starch vs. starch found in the endosperm (i.e., flour portion upon wheat milling), and phenolic compounds found in various wheat genotypes grown in Michigan.

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
2016	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
In packaging systems, chlorine dioxide gas is used for vapor-phase decontamination in treating produce before packaging and sanitizing products inside their packages. Yet very little is known about its effects on packaging material properties and performances. In terms of the containers

themselves, use of a reusable, plastic-based packaging system would greatly reduce the costs associated with packaging and address environmental issues.

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

Results
The goals of this study were to investigate: (1) the shelf life of blueberries in protein-based pouches, and (2) the stability of the protein-based pouch properties under vending machine conditions (7?C and 36% RH) for 9 days. Protein-based films were produced using the compression technique and then heat sealed to form protein-based
pouches, with the same dimensions as commercial pouches used to sell produce in vending machines. The weight loss, firmness, and microbial growth of the packaged blueberries were determined over time. Pouch properties of interest in food packaging (e.g., seal strength, thermal transition changes, and water and gas permeability) were assessed over time as well. The results showed that the studied protein-based pouches are a viable packaging alternative for blueberries commercialized
in vending machines.

During the current reporting period a self desinfecting surface was developed. In this specific proof of concept an antibiotic (ampiciline) was used as an active ingredient. The self desinfecting surface was accomplised by functionalizing the monmorelonite nanoclay with the active ingredient, the functionalize clay was disperse in a coating that was applied in a polymer material. The corner stone of this project is the ability to graft on the nanoclay and also to be able to release all
ampiciline that is grafted. The active surface was efficient in reducing the microorganism that came in contact with the surface.

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
2016	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Michigan, along with many other states, continues to work on revitalizing its economy. A critical component of the state's and the nation's revitalization effort is to decrease dependence on foreign oil, while creating jobs and encouraging further alternative energy investments. These efforts will have a significant impact on agriculture and manufacturing throughout the Great Lakes region and beyond, as sustainable alternatives to petroleum-based products are developed to strengthen the state's economy.

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
Survey biomass varieties and pyrolysis operating conditions to determine plant species and process parameters that yield favorable bio-oil characteristics and system economics The Saffron group participates on a project through the Great Lakes Bioenergy Research Center that is investigating the use of electrocatalysis to first deconstruct corn stover-derived lignin, and then reduce the products into fuels and chemicals. In this regard, we have evaluated a number of model compounds that become saturated by hydrogen at mild conditions of 1 atm and 80°C. This work will be extended to additional biomass varieties in future experiments.

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
2016	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
{No Data Entered}

What has been done
{No Data Entered}

Results
{No Data Entered}

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 2015-16 fiscal year, ABR and MSUE were able to 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 600 in 2015. Project GREEEN funds supported operational upgrades including strategic network and system modernization, as well as routine weather network maintenance. Sixteen Enviro-weather stations were upgraded with new loggers and sensors in 2015-16. Two new stations were added to the Enviro-weather network: Deerfield in September 2015 and Elbridge/Hart in May 2016.

Project GREEEN funds are used by the Land Management Office to help keep MSU AgBioResearch centers operating at full capacity. Funds are often used for new equipment and skilled labor positions. Many research centers were able to provide maintenance and repair services to infrastructure in 2015-16 through Project GREEEN, as well as funding for field trials, pest management and more. Numerous research center projects also benefited from Project GREEEN dollars, including:

- Monitoring for invasive grape pests.
- Sweet cherry bacterial canker research.
- Spotted wing drosophila monitoring in fruit crops.
- Trevor Nichols Research Center field lab renovations.
- Clarksville Research Center asphalt replacement and repair.

Together, MSUE and ABR continue to serve as the primary research and development arm for the agriculture and food industries in Michigan, valued at more than $100 billion annually.

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 MSUE evaluation results:

Powering Michigan Agriculture with Renewable Energy Conference

Conference purposes

The Powering Michigan Agriculture with Renewable Energy Conference was held Thursday, March 10, 2016 at the MSU Kellogg Hotel & Conference Center, East Lansing, Michigan. The purposes of the conference were to help farmers learn about various renewable energy technologies, identify the most suitable technology to meet their energy management goals, and obtain resources and tools necessary to implement these technologies on their farm.

Conference rationale

Farming operations use an extraordinary amount of energy. According to the USDA, energy requirements can be as much as 34% of a farm's total costs. Implementing energy conservation practices and renewable energy technologies recommended by an agricultural certified energy efficiency audit significantly reduces energy consumption and expense. From 2010-2014, Michigan farms that implemented recommended energy conservation practices (231 farms) and renewable energy technologies (122 farms) experienced, on average, a 43% and 74% reduction in energy expenses respectively. Completed certified energy efficiency audits are required before farmers can access utility rebates and government grants and loans to help pay for recommended energy conservation practices and renewable energy technologies. Agricultural production represents approximately 6.7% of Michigan's total energy consumption. At best, only 0.5% of Michigan farms have completed a certified energy efficiency audit for their operation. Michigan farms and the state's economy and environment all stand to benefit greatly from both improved energy use efficiency and increased capacity for renewable energy generation.

Conference summary

Just before adjourning the conference a farmer in the audience stood up and asked me if he could speak. I gave him the floor and he said he had attended many Extension programs over the years and was familiar with the standard of excellence Extension sets for their programs. As he made the statement he brought his hands up level with his chest to illustrate his feelings about the quality of Extension programs. He continued on and said that this conference was the best Extension program he had ever attended, and as he made that statement he raised his hands above his head. He thanked me for putting on such an excellent conference and as he said that attendees broke out in spontaneous applause. It nearly brought tears to my eyes to receive such appreciation for all the work that went into putting the conference together.
Overall, I was pleased with how the conference turned out. Sean Babington, Senior Professional Staff from Senator Stabenow's office, spoke during lunch and brought the Federal perspective on renewable energy and energy conservation into the conference. The presenters were prepared and each one did an excellent job providing educational information. The farmer panel was outstanding and in my opinion, was the highlight of the conference. These sentiments were reflected in some of the comments from the evaluation. A summary of the comments is provided later on in this report. Registration went smoothly. There were no problems with the AV equipment and the food was tasty. There was one vendor who wanted his money back because he only got one lead. His request was denied.
Michigan farmers were the target audience for this conference. An attendance goal of 100

participants was set during the planning phase. Eighty three individuals attended the conference. That said, farmer turnout was low, notwithstanding a huge media push to reach farmers (see Indirect report in MiPRS). This was extremely disappointing to me. I don't know if the low turnout was due to sending the wrong message to farmers or due to economic factors. I know commodity prices are low right now. However, the opportunity to save real money should have resonated with farmers.
I received enough feedback from individuals who attended the conference to justify holding another one next year. Some things I will do between now and then to improve the conference include:

- Analyze the message I want to send to farmers ahead of next year's conference.
- Survey vendors and sponsors for feedback on improving conference.
- Organize a larger and more diverse planning committee.
- Incorporate appropriate suggested improvements from the conference evaluation into the next one.
- Explore putting vendors together from other conferences going on the same day to maximize attendee contact.

Conference evaluation

An evaluation was distributed to conference participants (not vendors or sponsors). Evaluation results are provided below. One of the desired outcomes of this conference was for farmers to self-identify themselves as motivated to conduct an energy audit and/or invest in a renewable energy project such that I would be given permission to contact them after the conference to find out if they completed an audit or began their renewable energy project. Four farmers gave me permission to follow up with them. They will be contacted this summer and again 12 months later to find out if any recommended energy conservation practices were implemented and get a progress report on renewable energy projects. Potential short and long term impacts as a result of attending this conference include:

- Potential short-term impacts
  - Raise awareness of the need for and benefits of an agricultural certified energy efficiency audit.
  - Raise awareness of renewable energy technology options available to farmers.
  - Raise awareness of funding options to implement recommended energy conservation practices and renewable energy technologies.
- Potential long-term impacts
  - Farmers complete an energy audit.
  - Farmers implement recommended energy conservation practices.
  - Farmers select a renewable energy technology and implement it.
  - On-farm energy use (BTU's or KW) is reduced.
  - On-farm energy expenses are reduced (change in dollars expended on energy).
- Outcome indicators influenced
  - Farmers adopt new practices and use tools that improve energy use efficiency.
  - Farmers implement appropriate renewable energy technology(s).

Evaluation results

Thirty-seven evaluations were returned with usable data. A summary of the data is as follows:

- As a result of attending this conference, my overall understanding of renewable energy technologies has: (n=37)

- Increased (57%)
- Considerably increased (24%)
- Somewhat increased (14%)
- Not changed (5%)

Note: Farmers answered all the questions in the evaluation. Non-farmers skipped questions 2-8 and answered only questions 9 through 12.

- As a result of attending this conference, I am confident in choosing a renewable energy technology for my farm: (n=15)

  - Agree (73%)
  - Strongly Agree (21%)
  - N/A (Vendor) (6%)
  - Disagree (0%)
  - Strongly Disagree (0%)

- Please rank the factors listed below on their importance in determining whether to implement a renewable energy or energy conservation project on your farm (1 = most important to 5 = least important).(n=12)

  1. Return on investment.
  2. Upfront costs before reimbursement.
  3. Ease of obtaining rebates, grants and loans.
  4. Environmental benefits.
  5. Labor to operate equipment.

- As a result of attending this conference, I intend to implement a renewable energy technology on my farm within the next 12 months. (n=13)

  - Yes (7 respondents or 54%)
    - Solar (4), anaerobic digester (2), LED lighting (1), solar geo (1) and wood gasification (1)
  - No (3 respondents or 23%)
  - Maybe (2 respondents or 15%)
    - Solar (2), anaerobic digester (1), and wind (1)
  - N/A (1 respondent or 7%)

- As a result of attending this conference, I intend to conduct an energy audit on my farm. (n=12)

  - Within the next three months (2 respondents or 16%)
  - Within the next six months (0 respondents or 0%)
  - Within the next 12 months (3 respondents or 25%)
  - I do not plan on conducting an energy audit on my farm (2 respondents or 16%)
  - A farm energy audit has already been conducted on my farm (2 respondents or 16%)
  - N/A or Do Not Plan (3 respondents or 25%)

- If you indicated you intend to conduct an energy audit, would you allow Charles Gould to follow up with you to find out if an audit was completed and learn about your next steps? (n=8)

- Yes = 4
  - Nate Wortz, Central Grace Farms
  - Jim Anderson
  - Karen Warner, Big Head Farm
  - The fourth person did not leave any contact information.
- No = 3
- N/A=1

• If you indicated you do not intend to conduct an energy audit on your farm, would you briefly describe your reason(s) why?

- Not anticipating a return.
- Increase efficiency.
- Small operator.
- Limited use and need.
- Unless applying for a grant that required it, I can self-perform, which I have.

• Are there barriers standing in the way of implementing a renewable energy project or energy conservation measures on your farm? If so, what are they?

- Master plan for energy production.
- Mostly costs as it's a new farm. I have to finance buildings and take on additional financing for energy improvements.
- Low electric use.
- Time and money.
- Small scale.

Another evaluation,

Issue (who cares and why)?

In June of 2015, a Client located in Kent County was given their 'conditional grant of inspection'. This is standard procedure for any facility that files for a federal grant of inspection. The 'conditional' portion is to give the establishment enough time to operate to make changes if necessary to their HACCP plans and processes and demonstrate to the Federal Government that they are capable of producing safe, wholesome product.

What has been done?

I assisted client with decision making document, validation of processes (in-house) and making changes to processes and procedures as they worked through the first days of being inspected

Results/Impact?

On 3/31/2016, the Front Line Supervisor issued the Full Grant of Federal Inspection to the facility.

What difference did it make - public value?

The Full Grant of Inspection allows the facility to expand on the number of days they will run as a federally inspected facility, give them the ability to expand their product offerings (they are working on poultry and fully cooked products as well) and provide more permanent employment to their associates.

Key Items of Evaluation

MSUE Institute Work Team Adult Outputs for this area:

Institute for Agriculture and Agribusiness

1,776 AABI-02. Business Management

16,280 Public Event, Breakfast on the Farm, Ag Literacy, Consumer Ed, etc.

Institute for Greening Michigan

2,505 GM-3. Government and Public Policy

423 GM-4. Entrepreneurship

Institute for Health and Nutrition

6,456 HN-2. Food Safety

AgBioResearch Key Items:

Our country (and others) is burdened with healthcare issues that are costly, both in financial and human terms. Among these issues: medication error, patient non-adherence/non-compliance and hospital/healthcare acquired (HAIs) infections add to escalating costs. The healthcare system is further burdened by the health ramifications resulting from an increasingly obese society. Research and ideas that diminish these issues will significantly impact rural and urban families economically and emotionally.

Reduce medication errors • Why? The Institute of Medicine (IoM) has reported medication errors as the 8th leading cause of death in the US, resulting in 44,000-98,000 deaths annually. [1] While many contributing factors have been identified, drug name confusion and confusion relating to packaging and labeling are commonly indicated as inciting factors [1,2].

•Enhance patient adherence to medical regimens

• Why? It has been suggested that 50% of medications taken for chronic disease are not taken as prescribed [3-5] and that non adherence rates are even higher in developing nations [6]. These incidents are exacerbated by global trends such as: the aging of the population, and increasing complexity of medical regimen. This has led researchers and the World Health Organization (WHO) to report, "Increasing the effectiveness of adherence interventions may have a far greater impact on the
health of the population than any improvement in specific medical treatments." [6,7]

•Reduce hospital/healthcare acquired infections (HAIs)

• Why? HAIs, or infections acquired while an individual is a patient at a hospital that was neither present nor incubating in the patient prior to receiving service there, have been referred to as "one of the most serious patient safety issues in healthcare today." [8] Stone [9] estimates that the overall annual direct costs to US hospitals alone resulting from HAIs to be between $28- 45 Billion. The problem has been predicted to grow in future years, "HAIs have increased by 36% in the last 20 years and are consuming more health care dollars each year" [10] due to an increase in invasive procedures and growing resistance to antibiotics.

•Induce healthier food selections

• Why? Current trends predict that over 86% of US adults will be overweight or obese by 2030 [11]. Given the increased rates of morbidity, mortality [12] and health costs associated with obesity [13-15], creative approaches to curb this epidemic are needed.

Although packaging may not be the most obvious response to these issues, it has the potential to favorably impact them. It is for this reason that it is a rich area for investigation. Few have focused on packaging as a way to mitigate the impacts related to these issues. That is precisely why it is a rich area for research.

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.