2014 Michigan State University Combined Research and Extension Annual Report of Accomplishments and Results

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I. Report Overview

1. Executive Summary

Michigan State University AgBioResearch (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 300 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.

Agriculture is Michigan's second largest industry. 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 2013-14 resulted in an additional $2.06 in federal funds and external contracts, grants and other revenues to serve Michigan residents. During that fiscal year, ABR secured $60.4 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.

At the same time, Michigan **farmers and food processors continue to report that they are optimistic about the future of their industry, according to the "Michigan Agriculture and Food Index"** completed by economists from the MSU Product Center. The index gauges the current business climate of the state's food and agricultural system. A rating of 100 on the index is considered neutral; ratings above 100 signal increasingly positive confidence, and below 100, increasingly negative confidence. **Respondents gave the overall state of food and agriculture a rating of 146, compared to Michigan's overall economy at 120**. More than 80 percent of respondents are positive or very positive about the state of the system. Members of the roundtable are generally bullish on the current state of their industries. All major sectors of the state's food and agriculture system are represented in the survey: dairy, livestock, field crops, fruits and vegetables, and the nursery, floriculture and landscape industry.

In the FY2013-2014, **the state's $56.3 million investment in ABR and MSUE generated more than $867 million 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.

Further support of of MSU AgBioResearch and MSUE working together can be seen in their joint 2013-14 Legislative Report at: http://agbioresearch.msu.edu/uploads/396/36242/Compressed_Leg_Summ.pdf

MSU AgBioResearch 2014 Quick Facts:

126 Hatch-funded researchers representing 69 FTEs
253 active projects
72 patent applications submitted
24 patents received
281 peer-reviewed publications

Key Research Accomplishments for FY 2014 include:

Responding to Invasion: MSU shields fruit tree industry against tiny fly with big impacts. In partnership with several MSU AgBioResearch scientists and MSU Extension educators, Rufus Isaacs has developed an effective management program that equips Michigan growers with tools to help protect their fruit. Over the past four years, Isaacs and his colleagues have identified the most effective insecticides, first in a laboratory setting and then later in blueberry field tests at

TNRC. Eventually, they partnered with local growers to confirm their findings.

Good Egg Versus Bad Egg: Understanding the makings of a high quality oocyte
Women are born with about 2 million eggs in their ovaries. By age 30, about 90 percent of those eggs will be gone. By age 40, only about 3 percent remain. Michigan State University (MSU) AgBioResearch scientist Keith Latham has spent the past two decades closely studying immature eggs -- properly called oocytes -- primarily in animals, but with findings often applicable to humans. He began his research lab more than two decades ago to study how life begins and, ultimately, to determine what makes a high quality egg.
Long fascinated with the concept of development, Latham recounts first realizing how similar, yet different his hands were from each other and the wonderment at how that happened. This early curiosity inspired Latham eventually to pursue undergraduate and doctoral degrees in biology, and a career devoted to the detailed molecular studies of oocytes, as well as embryos and stem cells in mammals. Much of his research has been conducted on mice.

Risky Business: Training researchers to access dangerous microbes
Even as the global population surpasses 7 billion, humans are vastly outnumbered by the trillions of microorganisms on the planet. Many are essential for everyday life, but large numbers of these invisible creatures present significant health risks. Michigan State University (MSU) AgBioResearch scientist Jade Mitchell has coordinated a program to train fellow scientists to assess microbial risks and to assemble plans to help keep people safe. Mitchell, an assistant professor in the MSU Department of Biosystems and Agricultural Engineering (BAE), has developed a 10-day workshop to provide quantitative microbial risk assessment (QMRA) tools, models and training to university researchers around the nation.

Paradigm Shifts: Re-envisioning agricultural landscapes to optimize ecosytem services
In 2013, the United Nations released a report projecting that the global population will reach 9.6 billion by the year 2050. This increase of 2.4 billion people between now and then is already beginning to challenge the world's agricultural communities to provide adequate food, fuel and fiber while employing sustainable practices that conserve natural resources. The feat becomes more complex when coupled with the increasing demand to grow more bioenergy crops, combat biodiversity declines and regenerate the habitat of agriculturally important insects.

Doug Landis, Michigan State University (MSU) professor of entomology, is leading an interdisciplinary team of scientists in a multiyear investigation to explore the role of perennial bioenergy crops in supplying a host of services rising in demand.

Putting Soil to Work: Practical Soil Research Yields Major Soil Health Improvements
Practiced on farms of the Middle East since at least 6,000 B.C., crop rotation is a key element of agriculture. Producers have long known that alternating crops in their fields, rather than growing the same crop year after year, improves their farms dramatically. Benefits range from rejuvenating soil nutrients to controlling pests and preventing soil erosion, all of which add up to improved yields and better, healthier crops. There is still more to learn about crop rotation, and Michigan State University (MSU) researchers at the Living Field Laboratory (LFL) are developing the next phase of knowledge about the ancient practice. LFL was established in 1993 at the Kellogg Biological Station near Gull Lake under the direction of Richard Harwood, who was then the C.S. Mott Sustainable Agriculture Chair at MSU. The project was designed as a long-term study of the potential benefits of including cover crops in the rotation cycle of corn. The first crops were planted at the site in 1994 and crops planted there since have been diligently observed for the past 20 years. MSU AgBioResearch scientist Sieg Snapp took over LFL when Harwood retired in 2006.

Weather & Climate: Managing two of the most uncontrollable factors in agriculture

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.

State climatologist Jeff Andresen has worked directly with farmers to help manage and project the impact of weather and climate conditions on agricultural production systems since coming to Michigan State University (MSU) in 1991.

Redesigning Genetic Technology: Efforts Aim to Cut Costs, Improve Accessibility
Worldwide, pork is the most widely consumed meat; in the United States, it ranks as the third most popular.* In Michigan alone, the pork industry is worth over $362 million, according to the 2012 U.S. Census of Agriculture. Throughout a 300-year history in North America, pork producers have continually worked to improve their ability to meet this high global demand through improved feeding, housing, health and conventional breeding methods.

First domesticated more than 10,000 years ago, pigs are receiving a breeding kick start thanks in part to research to develop low-cost tools to analyze the animals' genomes. New technology pioneered by Michigan State University (MSU) AgBioResearch geneticists Juan Steibel, Ron Bates and Cathy Ernst will allow breeders to better understand the genetics of their animals and increase the efficiency of their breeding programs.

Note, the above stories are taken from our 2014 Annual Report--which is truly designed to highlight the best work of our researchers for the year. To see the complete stories, please visit: http://agbioresearch.msu.edu/uploads/annual_reports/AgBioAnnualReport14.pdf

MSU Extension 2014 Quick Facts:

910 staff representing 615 FTEs with 115 FTEs funded through 3BC
83 counties covered
818,664 youth participated in MSU Extension programs
143,134 adults participated in workshops and formal trainings
17,042 adult volunteers assisted 4-H programming

Key Extension Accomplishments for FY 2014 by Institute and Work Team:

Institute for Agriculture and Agribusiness
39,695 adults educated by Animal and Plant Production/Environmental Quality
5,359 adults educated by Business Management

Institute for Children and Youth
181,664 youth received experiential education in 4-H
6,737 adults trained by Academic Success
2,348 adults trained by Capacity Building
571 adults trained by Career Education/Work Force Preparation
1,566 adults trained by Leadership & Civic Engagement

Institute for Greening Michigan
6,353 adults educated by Sustaining Community Prosperity
3,392 adults educated by Natural Resources Stewardship
4,056 adults educated by Government and Public Policy

4,393 adults educated by Community Food Systems
4,179 adults educated by Seagrant

Institute for Health and Nutrition
1,520 adults trained by Disease Prevention and Management
7,329 adults trained by Food Safety
52,304 adults trained by Nutrition and Physical Activity
3,332 adults trained by Social and Emotional Health

Total Actual Amount of professional FTEs/SYs for this State

Year: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	178.8	0.0	64.0	0.0
Actual	230.0	0.0	69.0	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, regional and national 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. In addition, three action teams were created to further enhance MSUE's the merit review process for improvement.

• **Strategic Connections & Communications Team -** This team will determine the best practices for strategic communications for MSU Extension employees, update existing communications tools and develop new ones to help us all build and maintain our strategic connections.

• **Issues Identification Team -** This team will frame the issue identification process that will be used with the district councils in the future. The process will help us pinpoint the issues that are important to the communities we serve and identify how MSU Extension can be involved in addressing them.

• **Team Member Accountability and Performance Feedback Team -** This team will work to improve MSUE's performance review structure and examine the role peer feedback should play in those reviews.

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**:

• **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.

• **Michigan Alliance for Animal Agriculture (M-AAA) is a new partnership between the MSU College of Agriculture and Natural Resources, College of Vet Med, 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.

• **Michigan Agriculture and Food Strategic Growth Partnership** -- which came about as a result of the 2011 Governor's Summit on Production Agriculture and the Summit for Food Processors, and included input from the agriculture industry and state government -- has developed a plan based on the Governor's five-year challenge to create a stronger and even more vibrant agriculture. The Strategic Growth Initiative grant program, a joint venture between the Michigan Department of Agriculture and Rural Development and the Michigan Economic Development Corporation, is part of that initiative. ABR and MSUE are the one of the primary recipients of those grants.

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 2013-14 programming year, Product Center professionals conducted 4,947 counseling sessions with 589 clients. This lead to:

• 72 new venture launches.
• More than $3 million in total capital formation, including more than $2.8 million of owner investment in Michigan businesses.
• 208.5 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 skill sets 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.

MSUE completed a major restructuring effort in 2011-2012 . The effort was underpinned by commitments to reducing administrative overhead, maintaining organizational agility, and responsiveness, accountability to stakeholders, and continued emphasis on focused, effective educational programming across the state. Throughout this process, MSU Extension staff participation was encouraged by publishing weekly newsletters from the MSU Extension director to share information on the progress of the restructure and to solicit staff feedback; using the MSU Extension portal to post information and collect feedback from staff; and holding five town hall meetings and five meetings with local stakeholders at various locations across the state to discuss the restructuring plan and solicit staff input to guide the plan and identify and develop four new institutes within the MSU Extension framework:

• Preparing Michigan's Children and Youth for the Future
• Enhance Michigan's First Green Industry: Agriculture and Agribusiness
• Improve Health and Nutrition for Michigan Residents
• Greening Michigan: Leveraging Natural and Human Assets for Prosperity

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 into 2015. In addition, three action teams were created to further enhance MSUE's stakeholder input process for improvement.

• **Strategic Connections & Communications Team -** This team will determine the best practices for strategic communications for MSU Extension employees, update existing communications tools and develop new ones to help us all build and maintain our strategic connections.

• **Issues Identification Team -** This team will frame the issue identification process that will be used with the district councils in the future. The process will help us pinpoint the issues that are important to the communities we serve and identify how MSU Extension can be involved in addressing them.

• **Team Member Accountability and Performance Feedback Team -** This team will work to improve MSUE's performance review structure and examine the role peer feedback should play in those reviews.

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.

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 abreast of 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, 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.

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.

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 State University 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.

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.

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. Into refine our programs and strengthen infrastructure. 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.

Brief Explanation of what you learned from your Stakeholders

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. From an operational perspective, ABR has used stakeholder input to guide its decision making process around our core programs and research infrastructure.

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.

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.
- Attracting and retaining talent is critical to the future of the industry.

IV. Expenditure Summary

1. Total Actual Formula dollars Allocated (prepopulated from C-REEMS)			
Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
9186571	0	6550398	0

2. Totaled Actual dollars from Planned Programs Inputs				
	Extension		Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	10332319	0	6536367	0
Actual Matching	10332319	0	6614534	0
Actual All Other	0	0	23753022	0
Total Actual Expended	20664638	0	36903923	0

3. Amount of Above Actual Formula Dollars Expended which comes from Carryover funds from previous				
Carryover	3747726	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%		8%	
702	Requirements and Function of Nutrients and Other Food Components	0%		4%	
703	Nutrition Education and Behavior	10%		3%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources	2%		8%	
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins	3%		5%	
721	Insects and Other Pests Affecting Humans	0%		2%	
723	Hazards to Human Health and Safety	5%		12%	
724	Healthy Lifestyle	30%		12%	
801	Individual and Family Resource Management	10%		0%	
802	Human Development and Family Well-Being	10%		10%	
803	Sociological and Technological Change Affecting Individuals, Families, and Communities	2%		10%	
805	Community Institutions and Social Services	3%		18%	
806	Youth Development	20%		8%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	99.6	0.0	11.0	0.0

Actual Paid	122.0	0.0	9.6	0.0
Actual Volunteer	43.3	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**
5189831	0	904240	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
5189831	0	915054	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	3285991	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.
• Increase understanding about risk factors for youth transitioning from foster care.
• Increase understanding on how diversity, gender and sustainability impact U.S. agriculture.

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?

All MSUE field educators and specialists are encourage to be involved in eXtension through both Ask an Expert and Communities of Practice (CoP). A total 31.78 fte's were involved in this area of human health and youth development with 13.96 fte's funded through 3bc funds. Examples include:
Title of Questions: How will my costs for health care insurance be affected under the Affordable Care Act and Medicare?
Question: At retirement, I will go onto Medicare Part B, and my current employer-paid health insurance will become secondary. I am concerned my costs will increase under Medicare. Is there any data or FAQs I could look at to help me see clearly what some of my costs will be under Medicare with the ACA effect?
Response: Thanks for your question about Medicare part B. Suggest you go to the Medicare.gov website to look up the answer to your question. The Part B site is http://www.medicare.gov/your-medicare-costs/part-b-costs/part-b-costs.html that has detailed information about premiums by income and other specifics. The Medicare.gov site has lots of other useful information about this health insurance program, too. If you would like to talk to a local trained Medicare application person about your situation, suggest you contact the Area Agency on Aging or county Council/Commission on Aging in your area.
An example of CoP (Communities of Practices) Promoted two national MSUE Be SAFE webinars that were focused on issues of race and issues of gender/sexual harassment/bullying through eXtension Diversity Community of Practice which resulted in several participants attending from states outside of Michigan.

V(E). Planned Program (Outputs)

1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	71022	213066	67564	202692

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

Year:	2014
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2014	Extension	Research	Total
Actual	2	40	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
2014	35

Output #2

Output Measure

- Number of adult participants trained in healthy lifestyles.

Year	Actual
2014	53824

Output #3

Output Measure

- Number of youth participants trained in healthy lifestyles.

Year	Actual
2014	55197

Output #4

Output Measure

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

Year	Actual
2014	3332

Output #5

Output Measure

- Number of youth participants trained in life skills.

Year	Actual
2014	12117

Output #6

Output Measure

- Number of adult participants trained in youth development.

Year	Actual
2014	11222

Output #7

Output Measure

- Number of adult participants trained in family resource management.

Year	Actual
2014	4164

Output #8

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
2014	250

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
2014	13

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The World Health Organization estimates that nearly 350 million people, or approximately 5 percent of the global population, live with diabetes. It is the eighth leading cause of death, and by 2030, it is expected to jump to No. 7. People with diabetes are also at risk for developing a large number of health complications, such as kidney and heart disease, and vision loss. Approximately 29 percent of diabetic patients over the age of 40 will develop vision loss, or diabetic retinopathy.

What has been done
Research to: improve human, animal and plant health; understand the relationship between cancer and diet; relate family meals and lifestyle to obesity 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.

Results
One of the effects of diabetes is a condition called dyslipidemia, in which blood has abnormal levels and composition of cholesterol, triglycerides and other fat compounds, collectively termed "lipids."
An emerging trend in clinical trials is a link between dyslipidemia and retinopathy: as dyslipidemia worsens, the abnormal lipid composition exacerbates retinal damage.

Researchers are working to understand the correlation between the two conditions in the hopes of learning how to control and even prevent vision loss. Most lipids in the body are produced in the liver, but MSU researchers found that some lipids are actually produced at higher rates and present in higher concentrations in the retina than in the liver and blood. These enzymes produce long-chain fatty acids such as docohexaeonic acid (DHA), which protects retinal tissue from inflammation. Our lab further discovered that, in diabetic animal models, fatty acid elongases are down-regulated by more than 40 percent. Accordingly, the level of DHA was reduced by up to 40 percent in the retina, removing the tissue's protection from inflammation.

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
2014	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Michigan residents are exceptionally vulnerable due to chronic exposure to complex mixtures of endocrine disruptors that include legacy environmental contaminants within the Great Lakes basin(e.g., dioxin, PCBs, DDT), numerous pesticides and herbicides from the diverse and intense agricultural activities within the state, and the broad range of industrial activities that contribute to the overall pollution burden.

What has been done

Research to: comprehensively assess the toxicity of endocrine disruptors to determine the health risks of this contaminant to human health and wildlife in Michigan; study chronic respiratory diseases caused by air pollutants to better understand how nasal tissues and cells may respond to inhaled intoxicants;determine why some species of birds are more likely to support infectious agents than others; and to evaluate pesticide use and mitigate pesticide misuse to reduce environmental and human risk.

Results
We conduct face-to-face pesticide safety training programs and nearly 2,000 people paid to attend the programs this year. We also reached thousands of additional people each year in non fee-for-service events. We also reach 1000's of people though sales of over 6,500 training manuals.

4. Associated Knowledge Areas

KA Code	Knowledge Area
723	Hazards to Human Health and Safety
805	Community Institutions 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
2014	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Healthy, vital communities with active citizenry are better equipped to address the challenges facing many of today's families. Whether the issue is economic development, youth aging, family dynamics, demographics or rural and urban security, better models for the human health and human services sector are critical to human development and overall well-being.

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
We have written and published articles on breast cancer risk reduction. We also have participated in an outreach event to educate lay individuals about breast cancer risk reduction.

On another project, researchers are applying knowledge toward the MSU FAME program (Fostering Academics Mentoring Excellence). FAME is an on campus program for foster alumni provided for alumni of fostter care on the campus of MSU. The program provides support to young people who have trasnsitioned from foster care in the areas of academics, mentoring for social support as well as understanding the complexities and machinations of things like financial aide and personal budgeting.

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 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 Action Outcome Measure

3b. Quantitative Outcome

Year	Actual

2014 43059

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
A high prevalence of overweight and obesity has been documented among adults, especially among those living at or below the poverty level. Furthermore, a large proportion of adults in Michigan do not consume adequate fruits and vegetables. Limited income and poor nutrition could impact quality of life, and increase the likelihood of chronic diseases. Preventing or managing chronic diseases is the most important health challenge of the 21st century. Seven out of 10 deaths each year result from chronic diseases. More than 75% of healthcare spending (in Michigan and the U.S.) is for people with chronic diseases including heart disease, stroke, cancer, diabetes, kidney disease, and dementia. Leading a healthy lifestyle can greatly reduce the risk of developing chronic diseases.

What has been done
One example, MSUE provides nutrition education to diverse communities in Michigan. 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.

Results
Evaluation results found:

Dietary Intake (assessed using 24 hour food recalls)

- 42% of the adults completing the series demonstrate adoption of healthy eating practices by reporting an increase in fruit consumption during a typical day (1574 of 3723 participants).
- 50% of the adults completing the series demonstrate adoption of healthy eating practices by reporting an increase in vegetable consumption during a typical day (1893 of 3764 participants).
- 38% of the adults completing the series demonstrate adoption of healthy eating practices by reporting a positive change in whole grain consumption during a typical day (e.g., change from never to seldom, seldom to sometimes, sometimes to most times, and most times to always) (1470 of 3850 participants).

Fruit and vegetable intake (assessed using fruit and vegetable checklist)

- 33% of the adults completing the series showed improvement in consuming fruits or vegetables as snacks (459 of 1376 participants).
- 11% of the adults completing the series showed improvement in consuming citrus fruits or citrus juice during a typical week (147 of 1378 participants).
- 36% of the adults completing the series showed improvement in the amount of fruits consumed per day (495 of 1378 participants).
- 35% of the adults completing the series showed improvement in consuming more than one kind of fruit per day (474 of 1371 participants).
- 33% of the adults completing the series showed improvement in consuming more than one kind of vegetable per day (455 of 1369 participants).
- 36% of the adults completing the series showed improvement in the amount of vegetables consumed per day (496 of 1372 participants).
- 36% of the adults completing the series showed improvement in consuming two or more vegetables at their main meal per day (488 of 1370 participants).

Physical Activity

- 30% of adults completing the series demonstrated improvement in in the amount and level of physical activity on a weekly basis (e.g. changing from sedentary behaviors to moderately active or active) (414 of 1384 participants).
- 32% of adults completing the series demonstrated improvement in strengthening and stretching activities on a weekly basis (e.g. activities to increase muscle strength such as lifting weights, or activities to improve flexibility such as yoga) (449 of 1386 participants)

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 Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	27598

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Children and youth are at-risk in becoming obese and developing chronic diseases as adults unless they change their diets and physical activities.

What has been done
MSU Extension integrated work from the Health and Nutrition Institute with Children and Youth Institute (4-H) to create programs that emphasized healthy nutrition and physical activities.

Results
Evaluation results found:

- 32% of the youth increased their fruit intake
- 31% of the youth decreased their sugary drinks intake

- 34% of the youth increased vegetable intake
- 36% of the youth increased whole grain intake
- 30% of the youth increased time spent in physical activity
- 33% of the youth increased frequency of food safety practices

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
2014	2331

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Often times adults and parents need to increase knowledge and skills around anger management that give them constructive ways to deal with anger.

What has been done
MSU Extension offers RELAX as a series of sessions for participants (face-to-face and online) to provide alternatives to anger. Aspects of promoting social emotional health are woven throughout the training and include expressing emotions, navigating stress, resolving interpersonal conflict, taking another?s perspective, feeling capable and whole, and building skills for forming and maintaining satisfying, healthy and supportive relationships.

Results
Evaluation results from 435 surveys found:

- 61% decreased yelling and screaming at others
- 45% increased respect of others feelings
- 65% increased effort to talk things through until a solution is reached.

- 52% increased effort to work hard to be sure that those close are not hurt emotionally or physically.
- 60% increased knowledge of triggers for anger.
- 37% decreased feelings of walking away from conflict without feeling satisfied.
- 62% decreased efforts of making matters worse by bringing up an old issue.
- 61% increased effort taking time to understand how others feel.
- 62% increased effort working hard to be calm and talk things through.
- 61% increased effort if do get upset, try to end conflicts on a positive note.

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
2014	11209

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Children are needing core competencies as well as academic skills that help them communicate, problem solve, set goals, think critically and more. There is a need for experiential learning that leads to increased technical and core competencies.

What has been done
MSUE 4-H focuses one of its areas specifically on life skills, science and career exploration(sometimes separate and sometimes combined). Programs occurred throughout

Results
Evaluation results found:

- 1,591 (87%)youth participants indicated an increase in awareness of life skills and indicated the

ability to identify the life skills acquired.

- 1,574 (86%) youth participants gained self-awareness as it relates to future career possibilities.

- 1472 (88%) youth participants set a goals for their career or job.

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
2014	10756

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The Visual Arts and Sewing State workshops were combined as there are no state worksgroup under which these activities fall. These areas are important in emphasizing both technical (art and sewing) and core competencies (life skills)in youth development and goal setting.

What has been done
The Institute for Children and Youth Development Work Teams - The Career Exploration/Workforce Preparation, Academic Success and Leadership Civic Engagement shared in the development and orchestration of this event. Combining several goals of each work group developed the outcomes for this event.

Results
This workshop was attended by 154 attended including 96 adults, 50 youth and 8 MSU Extension staff from 37 counties. An evaluation toll was developed combining questions from each of the work group's evaluations. Results were then entered in each of the work group' survey monkey

tools. In addition, the following questions were aksed of adult participants:

Results/Impact?

Visual Arts and Sewing State Workshop Adult E valuation results

76 respondents- 71 female 5 male

As a result of participating in the Visual Arts & Sewing workshop

On a five point Likert type evaluation scale (Not at all, very little, some, quite a bit, a lot), the 76 survey respondents produced the following data:

I feel confident in my ability to help youth set and accomplish goals as it relates to visual arts projects.

60.5 % (46) indicated a lot

32.9 % (25) indicated quite a bit

I gained awareness and understanding of the concepts and skills necessary to run an arts project meeting (planning, goal-setting).

51.3% (39) indicated a lot

31.65% (24) indicated quite a bit

I understand how to assist youth in turning their 4H visual arts/sewing project into a business.

39.5% (30) indicated a lot

31.6% (24) indicated quite a bit

I am confident in my ability to integrate entrepreneurial concepts into 4H visual arts/sewing projects.

38.2% (29) indicated quite a lot

36.8% (28) indicated quite a bit

I am able to identify the connection between 4-H involvement and life skills development.

68.4% (52) indicated a lot

25 (19) indicated quite a bit

I will intentionally apply life skills into my work with youth in club activities and projects.

56.6% (43) indicated a lot

38.2% (29) indicated quite a bit

I feel confident in my ability to help youth be aware of the various careers that are available in fields that have connections to their interests, skills, and experiences.

53.9% (41) indicated a lot

31.6% (24) indicated quite a bit

On a four point Likert type scale (strongly disagree, agree, agree, strongly agree)

I learned about how entrepreneurial skills could be used in any career.

34.7% (26) strongly agree

64% (48) agree

I may consider pursuing further education about business/entrepreneurship.

27% (20) strongly agree

48.6% (36) agree

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
2014	12

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.

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; better understand the effects of climate on woody seedlings.

Results
Specific research goals were addressed in 2014 was the 2012-2017 Michigan Tourism Strategic Plan (MTSP). The MTSP was developed in 2012 via a process facilitated by myself, under the leadership of the Michigan Travel Commission, and in collaboration with the entire tourism industry.
Information presented to American Water Works Association Conference in Boston has resulted in contributed to a new initiative by the agency to improve community water and sanitation system capacity has led to a new initiative to make small community water system management and governance trainings less technocratic and more oriented toward whole system thinking.

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 Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	3331

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Many Michigan families are finding it difficult to make ends meet and sustain daily living. Some of the reasons for this are job loss, decreased income, increased mortgage or rent costs, rising food prices and lack of affordable credit. In order for communities to prosper it is important that individuals and families review their assets and liabilities and develop a plan to change their financial habits for a more sustainable existence. When individuals and families in our communities dare financially healthy, it creates an environment for sustained community prosperity.

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 practices?including managing a spending and savings plan and utilizing financial products and services in a beneficial manner and identify goals and the steps necessary to reach self-sufficiency. MSU educational programs also provide Michigan citizens with housing education that better prepares consumers for homeownership and retention of the home as an asset. Homeownership education and counseling has been shown to get buyers into lower-cost mortgages, increase credit scores, reduce defaults, improve borrowers' financial standing and increase the likelihood of troubled borrowers seeking foreclosure prevention assistance.

Results
One evaluation of 440 surveys in the homeownership education program found:

- 31% Made changes as needed, to improve credit report and score.
- 43% Saved money to prepare for home ownership.
- 36% Got a home inspected by a reputable firm.
- 46% Shopped around for the best home insurance coverage.
- 42% Identified the best type of mortgage for their needs.
- 43% Identified down payment and closing requirements for each type of mortgage loan.
- 52% Reviewed the HUD-1 to ensure that the fees were similar to those on the Good Faith Estimate.
- 25% Paid mortgage on-time every 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
2014	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Tuberculosis (TB) ? caused by Mycobacterium tuberculosis (MTB) ? is among the most common infectious diseases and frequently causes death worldwide, according to the CDC. It is estimated that one-third of the global population (2.3 billion people) is infected with latent TB, a form of the disease that has no symptoms but allows the bacteria to live in the body for decades. In the past 40 years, only one new drug has been successfully developed to treat TB.

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
When MTB infects humans, our immune system walls off the infection by building a granuloma ? a tumor ? around the bacteria, which is why you seem healthy if you have latent TB. MTB needs oxygen to grow. We believe the bacteria have the ability to sense when oxygen levels around them decrease ? a state known as ?hypoxia.? When they sense that the environment has become hypoxic, that?s their cue to hunker down.?
TB bacteria in this dormant, slow growing state are difficult to kill with antibiotics. Additionally, current therapies require patients to take antibiotics daily for six months. Missing several doses causes patients to remain ill longer and inadvertently breeds drug resistance.

To target MTB?s hypoxia-sensing ability, reseachers genetically engineered an MTB strain that glows green when it transitions to a dormant state. Robert Abramovitch was recently awarded the 2014 MSU Innovation of the Year award for creating this inventive assay, which he uses to screen for compounds that turn off the glow. Obstructing this signal indicates that a compound has successfully prevented the bacteria from sensing its hypoxic environment and entering a dormant state.

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
2014	149

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Safe Dates is a community education course that educates middle-school and high-school aged students on teen dating violence and abuse prevention.

What has been done
MSUE implemented Safe Dates that help teens understand the attitudes and behaviors associated with dating abuse and violence. Participants learn the difference between a healthy dating relationship and an abusive dating relationship, what causes dating abuse and its consequences. Participants learn skills and become aware of resources to help themselves or a friend involved in an abusive dating relationship. Teens also become familiar with methods to develop healthy dating relationships including positive communication, anger management and conflict resolution. The goal is to help teens develop healthy relationships through discussion and reflection of dating scenarios, and a variety of activities. The eight to ten sessions can take place in a school classroom, as well as a variety of other community settings. Published by Hazelden in 2006, the Safe Dates curriculum was chosen for the National Registry of Evidence Program and

Practices.

Results
Evaluation results found:

- 60% reported using what they had learned to improve their relationships with friends.
- 51% reported they learned ways to help a friend who is in an abusive relationship.
- 65% could name people and places that can help teens who are being abused in dating relationships.
- 33% learned new nonviolent ways to deal with anger.
- 12% used what they learned to end an abusive dating relationship
- 16% used what they learned to help a friend deal with or end an abusive relationship.

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 2013-2014 fiscal year, ABR and MSUE was able to start rebuilding some of its resources after several years of either flat or funding cuts at both the state and federal levels. ABR was able to **fill voids in its research and support teams by hiring quality, skilled people for a variety of positions ranging from farm managers and grant coordinators to faculty and research technicians**. **Much needed equipment and infrastructure updates were also conducted at many on-campus and outlying research facilities**, helping to keep operations to full capacity. In 2014, ABR and Project GREEEN funds helped bridge operating budget gaps at five of the 13 outlying research centers, enabling the repairs of equipment and several buildings. Together, the organizations look to re-invigorate the MSUE presence at the 13 outlying research centers throughout the state.

The **ongoing economic challenges** faced by Michigan continue to affect this planned program area. Consequences have included fewer new hires, delaying the award of new

financial obligations, reducing levels of continued funding, and renegotiating or reducing the current scope of assistance through formula funds or block grants. Specifically, a 15 percent decreases in state funding FY2011-2012 coupled with a flat federal funding line for the following two years resulted in the elimination of 72 Extension educator positions across 83 counties, 22 academic and faculty positions on campus and 15 support staff. Administrative positions were reduced from 45 to 19 FTEs. Impacts on ABR came largely in the form of reductions in research infrastructure support. Investments in facility maintenance and equipment were postponed in an effort to avoid eliminating more than 45 research positions (faculty, support staff and graduate assistants) and one research facility had to be closed in light of the reductions. There were also fewer funds to seed research on emerging issues.

Recent **extreme weather events** also caused extensive hardship to the agriculture industry. The spring 2012 ranks among the most destructive weather periods in Michigan fruit production history, with crop losses valued at more than $500 million. Peach production suffered a 95 percent loss; tart cherry, a 90 percent crop loss; apple production, an 88 percent loss; and grapes, an 85 percent loss. The summer 2012 brought the worst drought in Michigan since 1988 with many crops suffering substantial losses.
And the winter of 2013-14 brought a series of bitterly cold air masses rolled down from the Arctic, through Canada and into Michigan. The period between November 2013 and February 2014 was the coldest in Michigan since 1911 and among the five coldest periods on record in the state.

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

Research

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.

Extension

Another example of evaluations in this area:
Caregivers of Adults with Special Needs
Teachers or caregivers of adults with special needs were asked to complete a survey documenting their observations about adult behaviors since participating in our nutrition education program. A total of 33 teachers/caregivers completed the survey. Seventy three percent observed that participants were identifying food groups correctly. In addition, teachers/caregivers observed improvement in other nutrition-related behaviors that are essential for this group:
- 97% of the teachers reported that the participants increased in their **awareness of the**

importance of good nutrition.
- 79% reported that the participants were making **healthier meal and snack choices.**
- 73% reported that the participants were willing to **try new foods**.
- 64% reported that the participants were **eating more fruit**.
- 58% reported that the participants were **eating more vegetables**
- 42% reported that the participants were **eating more vegetables**

Key Items of Evaluation

Research

After four decades of research, scientists have yet to determine the exact cause of diabetic retinopathy. A metabolic condition, diabetes limits the body's ability to process sugar or glucose, leading to hyperglycemia. Researchers initially thought that this unhealthy increase in blood glucose was the sole cause of the retinal damage that leads to vision loss, but recent clinical trials have begun to reveal a different picture. One of the effects of diabetes is a condition called dyslipidemia, in which blood has abnormal levels and composition of cholesterol, triglycerides and other fat compounds, collectively termed "lipids." An emerging trend in clinical trials is a link between dyslipidemia and retinopathy: as dyslipidemia worsens, the abnormal lipid composition exacerbates retinal damage. MSU researchers are working to understand the correlation between the two conditions in the hopes of learning how to control and even prevent vision loss.

Most lipids in the body are produced in the liver, but MSU researchers found that some lipids are actually produced at higher rates and present in higher concentrations in the retina than in the liver and blood. These enzymes produce long-chain fatty acids such as docohexaeonic acid (DHA), which protects retinal tissue from inflammation. Our lab further discovered that, in diabetic animal models, fatty acid elongases are down-regulated by more than 40 percent. Accordingly, the level of DHA was reduced by up to 40 percent in the retina, removing the tissue's protection from inflammation. Researchers demonstrated that diabetic retinopathy can be prevented through a diet high in fish oil, which contains high concentrations of DHA. This approach, however, is far from practical outside of laboratory studies.

Researches are now working on the regulation of the enzyme pathways that boost DHA production in retinal tissue so that treatments for diabetic retinopathy can be developed that return patients' DHA levels to normal. Such treatments would prevent retinal dyslipidemia and, consequently, vision loss.

Extension

MSUE utilizes the Institute Work Teams for planning, evaluating and reporting. Work Teams in this area found:

Children and Youth Institute
- 3,337 youth demonstrated the ability to apply science knowledge and problem solving, critical thinking, and decision-making life skills.
- 483 adults and teen leaders indicated the ability to apply knowledge to engage youth in experiential, inquiry based science learning.
- 1,591 youth participants indicated an increase in awareness of life skills and indicate the ability to identify the life skills acquired.
- 1,472 youth participants set a goal for their career or job.
- 1,574 youth participants increased self-awareness as it relates to future career

possibilities.

Greening Institute

- 208 program participants indicated that they kept track of spending and income by creating a personal budget.
- 196 program participants indicated that they saved money regularly by spending less than is earned.
- 190 participants indicated they obtained, reviewed and corrected personal credit report.
- 164 participants indicated they paid bills on time.
- 169 participants indicated they pay down debt and adopt behavior changes that improved their credit score.
- 186 participants indicated that they are planning for retirement.

227 participants indicated that they can identify SMART financial goals.

- 716 new vendors, farm markets, road side stands that accept Bridge Cards, Project Fresh, and participated in Double Up Food Bucks as a result of MSUE efforts.
- 331 people with increased knowledge of community food systems and food hubs.
- 6,767 students served through the Food Corps program.

Health and Nutrition Institute

Dietary Intake (assessed using 24 hour food recalls)

- 1,574 of the adults completing the series demonstrate adoption of healthy eating practices by reporting an increase in fruit consumption during a typical day.
- 1,893 of the adults completing the series demonstrate adoption of healthy eating practices by reporting an increase in vegetable consumption during a typical day.
- 1,470 of the adults completing the series demonstrate adoption of healthy eating practices by reporting a positive change in whole grain consumption during a typical day (e.g., change from never to seldom, seldom to sometimes, sometimes to most times, and most times to always).

Fruit and vegetable intake (assessed using fruit and vegetable checklist)

- 459 adults completing the series showed improvement in consuming fruits or vegetables as snacks
- 147 adults completing the series showed improvement in consuming citrus fruits or citrus juice during a typical week (147 of 1378 participants).
- 495 adults completing the series showed improvement in the amount of fruits consumed per day.
- 474 adults completing the series showed improvement in consuming more than one kind of fruit per day
- 455 of the adults completing the series showed improvement in consuming more than one kind of vegetable per day .
- 496 of the adults completing the series showed improvement in the amount of vegetables consumed per day.
- 488 of the adults completing the series showed improvement in consuming two or more vegetables at their main meal per day.

Physical Activity

- 414 adults completing the series demonstrated improvement in in the amount and level of physical activity on a weekly basis (e.g. changing from sedentary behaviors to moderately active or active)
- 449 adults completing the series demonstrated improvement in strengthening and stretching activities on a weekly basis (e.g. activities to increase muscle strength such as lifting weights, or activities to improve flexibility such as yoga).

To see a more detail go to:
http://web2.canr.msu.edu/nec/lmprs/linkedFiles/NARR163682014%20MSUE%20HNI%20NPA%20Workgroup%20Evaluation%20Report.pdf

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	2%		5%	
102	Soil, Plant, Water, Nutrient Relationships	35%		12%	
111	Conservation and Efficient Use of Water	10%		12%	
112	Watershed Protection and Management	10%		10%	
123	Management and Sustainability of Forest Resources	10%		5%	
131	Alternative Uses of Land	2%		6%	
132	Weather and Climate	2%		10%	
133	Pollution Prevention and Mitigation	5%		12%	
134	Outdoor Recreation	2%		1%	
135	Aquatic and Terrestrial Wildlife	2%		12%	
216	Integrated Pest Management Systems	10%		15%	
806	Youth Development	10%		0%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	10.2	0.0	11.0	0.0
Actual Paid	18.0	0.0	11.7	0.0
Actual Volunteer	2.5	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**
851134	0	1110924	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
851134	0	1124209	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	4037075	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?

All MSUE field educators and specialists are encourage to be involved in eXtension through both the Ask an Expert and Communities of Practice (CoP). A total 7.73 fte's were involved in this area of soil, water and natural resources with 3.62 fte's funded through 3bc funds.
An example:
Question: IN WHAT ORDER DO YOU ADD SEED MANURE AND WEED KILLER IN THE SPRING
Response: Hello,
I am sending links to two articles that will help answer your question. It may be that you can avoid using any herbicide through management practies, and you may want to soil test to see if you even need to add nitrogen to the soil.

If you do need to use herbicide, you want to do it when the weeds are still fairly small (which they still may be in Houghton).

http://extension.psu.edu/animals/equine/pasture-weed-management/basic-pasture-management-for-the-equ...

http://msue.anr.msu.edu/news/5_guidelines_for_managing_spring_horse_pastures_in_2014

V(E). Planned Program (Outputs)

1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	8024	24072	48169	96338

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

Patent Applications Submitted

Year:	2014
Actual:	3

Patents listed
MICL01821: Microbial Ecology and Genomics of Soil Bacteria #14/015,787 (8/13/13); MICL02373: Development of Biodegradable and Compostable Nanocomposites#14/233,314(4/29/14); MICL01574 :Movement and Degradation of Organic Contaminants and Pesticides in Soils and Sediments #8633133 (1/21/14)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2014	Extension	Research	Total
Actual	2	48	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

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

Year	Actual
2014	43

Output #2

Output Measure

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

Year	Actual
2014	453

Output #3

Output Measure

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

Year	Actual
2014	7571

Output #4

Output Measure

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

Year	Actual
2014	48169

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
2014	3

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Soils constitute a huge reservoir of microbes, whose activities have a profound impact on crop productivity, soil fertility and biogeochemistry. However, knowledge of the composition, organization and fluctuations of indigenous microbial populations in soil ecosystems is scarce, even though metabolism of such microbes drives many ecosystem level processes.

What has been done
Research to: understand temporal and spatial control of gene expression during development of soil bacteria; determine how well the most promising candidate strains of cereal-adapted rhizobia perform as superior biofertilizer innoculants for rice and wheat when scaled up to full-size farmer plots; investigate novel cultivation strategies and cultivation-independent techniques to advance our understanding of microbes and microbial communities in soils; and develop new technologies to control soil-borne diseases.

Results
Our research supports the use of alternative fertilizer management techniques in flooded agroecosystems by the mitigation of Nitrogen losses through denitrification and decreased overall Nitrogen flux rates.
A major accomplishment during this reporting period was the completion of the research to analyze various formulas used in ecology research to compute biovolume body mass, rank their accuracy under several testing conditions, and publish the results with recommendation of those formulas that perform with greatest accuracy and adaptability to various digital imaging conditions. That work has high impact to ecology researchers because the information gained (biovolume body
mass) represents a very significant metric for various ecological assessments.

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
2014	6435

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example in this area is regarding Michigan's 11,000 inland lakes. The state of Michigan simply doesn't have the resources in these economic times to manage these precious water resources. MSUE partnered with state to work on this need.

What has been done
MICHIGAN INLAND LAKES CONVENTION.

MSUE was involved in marshaling the passion and energy of volunteers across the state as well as organizations that work to help manage inland lakes by helping to organize the first Michigan Inland Lakes Convention. Target audience included lake enthusiasts, professionals, government officials, and educators. The convention helped participants learn how to become better stewards and protect Michigan's inland lakes. More than 25 sessions were offered, including a natural shoreline workshop as well as a septic workshop. The Convention was a partnership between MSUE, MDEQ, MDNR, Michigan Lake and Stream Associations, Michigan Natural Shoreline Partnership, MSU Institute of Water Research, and the Michigan Chapter of the North American Lake Management Society.

Results
373 people attended the Convention.

More than 66% represented nonprofit agencies or were riparian landowners.

More than 75% reported increased leadership, confidence and stewardship.

More than 90% reported they gained information that will assist them as professionals or volunteers.

Due to the overwhelming success of the event, the Partnership has agreed to make it a biennial event; the next Convention will take place in 2016.

http://msue.anr.msu.edu/news/lakes_convention_attracts_hundreds_of_lakeshore_owners_and_professionals

What difference did it make - public value?

Due to the overwhelming success of the event, the Partnership has agreed to make it a biennial event; the next Convention will take place in 2016.

http://msue.anr.msu.edu/news/lakes_convention_attracts_hundreds_of_lakeshore_owners_and_professionals

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
2014	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
A better understanding of wildlife-habitat relationships as influenced by natural and human wildlife habitat disturbances is needed in order to make more effective natural resources management decisions to sustain biodiversity and conserve wildlife populations, communities and habitat.

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.

Results
Research analyzed county-level data from five Midwestern states across 12 years and revealed a phenomenon ?the suburb effect:? communities with suburban landscapes experience more collisions and more severe ones than other types of landscapes. Deer live in close proximity to humans in suburban communities. Often, these communities infringe upon deer habitat, hunters don?t usually hunt in these areas, and traffic tends to be heavy in and surrounding these communities.

In suburban areas, you have the perfect storm of good habitat, a lot of deer and a lot of traffic. This phenomenon was consistent across all 12 years analyzed. Knowing that helps draw the conclusion that it may be worth investing in extensive, long-lasting mitigation efforts, such as building underpasses for wildlife to safely cross roads.

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
2014	394

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Citizens are looking for ways to make a difference in their communities. In addition, there is a great need to educate citizens regarding soil, plant, water and nutrient relationships.

What has been done
The MSU Extension Master Gardener Program (MGP) provides interested individuals with the chance to take part in a focused, 13-week training experience that provides in-depth education in many aspects of horticulture, including trees and shrubs, flowers, vegetables, fruit, soil, water, pests, indoor plants and lawns.

Individuals who complete the training can get involved in local gardening activities, sharing the joys of gardening with people of all ages, and teaching environmentally friendly gardening practices. Volunteers will have the opportunity to help other gardeners solve garden problems and participate in special projects that improve our communities.

After completing 40 hours of fun, rewarding community service, these participants earn their Extension Master Gardener certification, a widely recognized designation. Master Gardener Volunteers can then earn special recognition and awards and become leaders in their communities.

The MGP connects gardeners across Michigan to MSU resources. MSU is recognized as one of the nation?s top plant science teaching and research universities. In addition to the Master Gardener Training Program, university experts present a wide variety of seminars and classes that volunteers may use to enrich their lives and the lives of others.

Results
Evaluation of the Master Gardener College found

- 87% of the participants gained knowledge that influenced a number of new adoption of landscape practices that included:

-using native plants
-plant selection and placement
-enhancing pollinators through habitat enhancements
-spraying fewer pesticides
-raising their mowing height
-mulching leaves into their lawn
-reducing lawn areas
-replacing lawn with alternative plants
-incorporating water-wise practices into their landscape

A subset of questions were asked of attendees who participated in tours of horticulture

operations. (N=64) These questions were directed at the individual?s knowledge gained that would influence their purchase decision of MI horticulture products.

- 35% gained knowledge that would influence their purchasing decisions
- 30% made purchases of MI horticulture products as a result of participating in MG College.

Extension Master Gardeners have improved their communities through efforts that not only beautify but also increased food security and support community development. Residents trained through the Master Gardener Program become supporters of and advocates of MSU and MSU Extension.

Overall MSU Extension Master Gardener Program had over 3,000 Extension Master Gardeners from 76 counties that provided 376,986 volunteer hours to MSU Extension and their communities at an economic value of $8.32 M dollars. (This value was determined by using the Independent Sector's national value of volunteer time of $22.55.) These individuals have also pursued 92,278 hours of continuing education to ensure information shared is current, relevant and grounded in science.

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
2014	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Urban, industrial and agricultural development have caused remarkable changes in the lakes' flora and fauna and fauna associated habitats over the past 200 years. Today, the lakes have aquatic communities that are structurally and functionally volatile and exhibit rapid changes in species number and abundance. Successful fish management of the Great Lakes is now actively focused on the lakes as ecosystems.

What has been done

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

Results

In 2009, the Michigan Department of Natural Resources(MDNR) discovered that walleye in the Inland Waterway a 45-mile long network of four lakes and multiple rivers spanning private, public and Native American tribal land in Cheboygan County had greatly diminished since they were last surveyed in 1998. Returning the walleye population to a more sustainable level has become a priority because of their importance to
commercial, sport and tribal fishing in the area. Now, through the efforts of Michigan State University (MSU) AgBioResearch fisheries scientists, the MDNR and tribal fisheries managers are making more informed decisions to help the fish recover. They were able to learn about the movements of the fish through tagging and learn about the nutrition habits of these fish. They discovered a shortage of zooplankton in the Inland Waterway, escalated by invasive species such as zebra mussels that compete for the same resources, was limiting the population?s growth. With a more complete picture of their fishery in
hand, both the MDNR and the tribes are now able to make better decisions about the use of their shared resource.

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
2014	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.

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; and to improve design of engineered phytoecosystems for treatment of wastewaters and stormwaters.

Results
Before the advent of big data, ecologists commonly studied single sites, such as a specific lake or river. Though that approach yielded incredible insight into one site, a big data approach provides the opportunity to apply the detailed knowledge to entire systems. Bringing big data research into ecology will help researchers track the spread of
invasive species such as zebra mussels and Asian carp across waterways and from one freshwater system to another. By studying lake systems as a population, researchers can also gain insight into their significance
in larger issues such as climate change and the global carbon cycle.

Another study, investigating West Nile Virus (WNV), discovered that the disease was only in

certain locations ? it was not widespread across metropolitan areas. They gathered data on the number and location of
confirmed human cases of WNV and found that those locations correlated with areas where mosquito infections were also the highest. The group then categorized the urban landscapes by demography, density of houses
and types of buildings. When all of this information was combined, researchers could further delineate where, how and why the virus set up among human populations as well as using the weather (increased temperature and precipitation events). The hope is that the findings will guide public health decisions.

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
2014	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Understanding the variability of soil and landscape properties and their effect on crop yield is a critical component of site-specific agricultural and environmental management systems. This includes factors such as nitrogen management, soil absorption and environmental interactions.

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
Research showed that rotating crops and using reasonable levels of fertilizer could bring about beneficial changes in soil composition. Most improvements were not immediately apparent. After 20 years of study, their patience was rewarded. The researchers observed significant improvements in both the soil?s organic matter and nitrogen efficiency, reaching a new peak level of productivity. Researchers determined that the experiment was over when the soil would not improve beyond that point. It had reached a new plateau but was now operating on a much healthier, more productive level than ever before.

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
2014	8

3c. Qualitative Outcome or Impact Statement

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

viability and health, and minimizing consequences to human health.

What has been done

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

Results

Soil and surface waters are other important areas of investigation. MSU AgBioResearch soil chemist researches soil contaminants, including antibiotics. A key instrument in this work is a liquid chromatograph with tandem mass spectrometers (LC-MS/MS), which gives specific analytical information and has a higher throughput analysis than gas chromatography, another laboratory technique for the separation of mixtures. The LC-MS/MS, purchased with funds from MSU AgBioResearch and other sources for the lab, helps to identify antibiotics and many other pharmaceuticals in the environment and measure their quantities in water and soil.

Researchers have focused on emerging organic contaminants in soil and water, especially identifying and measuring antibiotics in the environment. Tetracyclines, broadspectrum antibiotics used in the treatment of numerous infections and also in animal feeding operations, are the focus of much of the research.

In another study, consideration of soil organic matter and clays as sorptive phases for pesticides in soils will allow development of better
pesticide fate and transport models. Polychlorinated dioxins, especially octachlorodioxin and the highly toxic 2,3,7,8-
tetrachlorodioxin, are found at inexplicably high levels even in "pristine" rural and agricultural soils, but their origins are
unknown. The potential for clay-mediated in-situ formation of dioxins has important implications for past, present and future
contamination of rural soils.

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
2014	4

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
We analyzed and subsequently better understood the role of land use and and cover change, as well as its interaction with climate, in the environmental assessment. Through process-based models and large-scale remote sensing technologies we better understood the spatial patterns of grassland degradation, water pollution, and soil sealing dynamics. We presented these research results in various conferences and used them as examples in anumber of international land use and land cover change training workshops.

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 2013-2014 fiscal year, ABR and MSUE was able to start rebuilding some of its resources after several years of either flat or funding cuts at both the state and federal levels. ABR was able to **fill voids in its research and support teams by hiring quality, skilled people for a variety of positions ranging from farm managers and grant coordinators to faculty and research technicians**. **Much needed equipment and infrastructure updates were also conducted at many on-campus and outlying research facilities**, helping to keep operations to full capacity. In 2014, ABR and Project GREEEN funds helped bridge operating budget gaps at five of the 13 outlying research centers, enabling the repairs of equipment and several buildings. Together, the organizations look to re-invigorate the MSUE presence at the 13 outlying research centers throughout the state.

The **ongoing economic challenges** faced by Michigan continue to affect this planned program area. Consequences have included fewer new hires, delaying the award of new financial obligations, reducing levels of continued funding, and renegotiating or reducing the current scope of assistance through formula funds or block grants. Specifically, a 15 percent decreases in state funding FY2011-2012 coupled with a flat federal funding line for the following two years resulted in the elimination of 72 Extension educator positions across 83 counties, 22 academic and faculty positions on campus and 15 support staff. Administrative positions were reduced from 45 to 19 FTEs. Impacts on ABR came largely in the form of reductions in research infrastructure support. Investments in facility maintenance and equipment were postponed in an effort to avoid eliminating more than 45 research positions (faculty, support staff and graduate assistants) and one research facility had to be closed in light of the reductions. There were also fewer funds to seed research on emerging issues.

Recent **extreme weather events** also caused extensive hardship to the agriculture industry. The spring 2012 ranks among the most destructive weather periods in Michigan fruit

production history, with crop losses valued at more than $500 million. Peach production suffered a 95 percent loss; tart cherry, a 90 percent crop loss; apple production, an 88 percent loss; and grapes, an 85 percent loss. The summer 2012 brought the worst drought in Michigan since 1988 with many crops suffering substantial losses.
And the winter of 2013-14 brought a series of bitterly cold air masses rolled down from the Arctic, through Canada and into Michigan. The period between November 2013 and February 2014 was the coldest in Michigan since 1911 and among the five coldest periods on record in the state.

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

Research
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.

Extension
Other examples of evaluation results:

ECONOMIC VALUE of the MASTER GARDENER BASIC TRAINING COURSE
For many years, anecdotal information has suggested that some people take the MSUE Master Gardener basic training course for economic reasons. To verify the economic value of this course, these observations have been documented through the course application process.
2014 Summary:
453 people from 41 counties attended 11 training courses in the following sites: Harper Woods (Wayne County), Novi (Oakland County), Mt Pleasant (Isabella County), Clinton Twp. (Macomb County), Grand Rapids (Kent County), Holland (Ottawa County), Traverse City (Leelanau County), Marquette (Marquette County), and East Lansing (Ingham County). N=435

- 19% (85) - enrolled in the MG course to enhance their profession
- 9% (40) - are currently employed by a green industry business
- 16% (40) - indicated that MSUE MG credentials and skills will help them in their current position
- 11% (52) - indicated that MSUE MG credentials and skills will help advance their position or employment
- 10% (46) - indicated that MSUE MG credentials will help market their business
- 20% (92) - indicated they are considering starting a green industry business or working in the green industry

This data documents the economic development value of the MSUE Master Gardener course and will help market the value of MSUE MG Programs to internal and external decision-makers.
Issue (who cares and why)? Advancing Great Lakes literacy and stewardship. A priority of both the National and Michigan Sea Grant strategic plans.
What has been done? Great Lakes Education Program
Results/Impact?
Program Evaluation - Teachers were asked to rate individual learning activities on a 1 (poor) to 4 (excellent) scale in terms of how well they help achieve curriculum goals. Average ratings ranged from a low of 3.54 to a high of 3.81, with a mean of 3.64 (3.42 to 3.68 for chaperones, with a mean of 3.57). When asked to rate the overall GLEP experience, the mean teacher response was 3.90 (3.81 chaperones). Teachers were asked to rate GLEP compared with other "field trip" experiences they have had on a 1 (much worse) to 5 (much better) scale, with the mean response being 4.55 (4.32 for chaperones). Teachers were asked how well GLEP education helps them meet Michigan educational benchmarks on a 1 (poor) to 4 (excellent) scale, with the mean response being 3.53. Of the 77% of teachers who reported using the GLEP curriculum, teachers completed an average of 2.5 learning activities prior to their field day, and an additional 2.0 following.
Behavior Change - Of the 80% of the teachers who had previously participated in GLEP education, 90% shared GLEP information with other teachers and/or school administrators; 62% sought more information on Great Lakes and/or ocean science; 71% included more Great Lakes and/or ocean science content in their classroom (beyond the GLEP curriculum); 89% encouraged other teachers to participate; 38% visited the Great Lakes more, 39% visited the Metroparks more often; and 94% felt a greater responsibility for the Great Lakes.
What difference did it make - public value?
Stewardship depends on understanding and experience with natural resources such as the Great Lakes.

Key Items of Evaluation

Research

Michigan State University (MSU) AgBioResearch evolutionary ecologist Kim Scribner studies lake sturgeon, a bottom-feeding Great Lakes fish species that can grow longer than 8 feet, weigh up to 300 pounds and live for nearly a century. Despite long lives, however, lake sturgeon populations have been in serious decline since the late 19th century. The U.S. Fish and Wildlife Service reports that in 1910, 80 percent of the species had disappeared from Lake Erie, and by 1929 the amount of sturgeon caught in Lake Michigan had dwindled from 3.8 million pounds to just 2,000. Numerous causes for the sturgeon decline are known. Scribner and his research team are trying to find a way to bring back the ancient fish.
"Sturgeon migrate from the Great Lakes to the rivers for spawning, which makes them an important part of that coupled ecosystem," he said. "The species is a poster child for humans decreasing the population through overfishing and pollution, and we're trying to help turn that around."
Though female lake sturgeons lay thousands of eggs at a time, Scribner's team has found that 95 to 98 percent never survive to hatching, and of those that do, 99 percent die in the larval stage. Those survivors must live 15 years before achieving sexual maturity and the ability to reproduce.
"Our primary focus is finding the factors that limit sturgeon survivability in the early stages of their life cycles," Scribner said. "If we can identify the sources of mortality, we can create better management plans to help increase their numbers."

Extension

MSUE utilizes the Institute Work Teams for planning, evaluating and reporting. Work Teams in this area found:

Children and Youth Institute

- 3,337 youth demonstrate the ability to apply science knowledge and problem solving, critical thinking, and decision-making life skills.
- 483 adults and teen leaders demonstrate the ability to apply knowledge to engage youth in experiential, inquiry based science learning.
- 1,591 youth participants increased their awareness of life skills and demonstrated the ability to identify the life skills acquired.

Greening Institute

- 2,185 adult and youth participants implement a practice to mitigate an ecosystem threat.
- 288 participants show improved awareness or knowledge of NR or ecosystems.
- 120 participants initiate or contribute to ecosystem-related planning in their local area.
- 113 adult and youth participants indicate a high or very high level of understanding of potential human impacts on ecosystems and ecosystem health.
- 98 Sea Grant facilitated curricula adopted by formal and informal educators.
- 373 formal and informal educators engaged in Sea Grant supported professional development.

Agriculture and Agribusiness Institute

- 4,133 new acres under irrigation management
- 2,386 improved existing irrigation system
- 1,052 new adoptions of sustainable landscapes
- 156,143 change in nutrient use (lbs)
- 783,881,672 change in water use (gallons)*
- 51,989 change in $ expended on water withdrawal
- 49,049 change in $ expended on energy

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%		9%	
204	Plant Product Quality and Utility (Preharvest)	10%		5%	
205	Plant Management Systems	45%		10%	
206	Basic Plant Biology	10%		10%	
211	Insects, Mites, and Other Arthropods Affecting Plants	5%		13%	
212	Diseases and Nematodes Affecting Plants	5%		11%	
215	Biological Control of Pests Affecting Plants	5%		5%	
216	Integrated Pest Management Systems	10%		15%	
806	Youth Development	10%		0%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	30.1	0.0	19.0	0.0
Actual Paid	34.0	0.0	22.8	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**
1655340	0	2144342	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1655340	0	2169985	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	7792493	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?

All MSUE field educators and specialists are encourage to be involved in eXtension through both the Ask an Expert and Communities of Practice (CoP). A total 16.56 fte's were involved in this area of plant sciences with 8.77 fte's funded through 3bc funds.
An example is one educator reports he/she was involved in the Blueberries CoP where a Michigan Blueberry Facts sheet with an Ask an Expert Widget generated over 200 Ask an Expert queries with about half originating outside of Michigan.
For example,
Title of question: **blueberry soil ph**
Question: willl a soil ph of 6.5 will n/p/k still be available to the plant? is availability of all nutrients and micronutrients tied up and unavailable with a high soil ph in blueberries?
Response: Yes N-P-K will still be available. At that pH the plants show a severe iron deficiency with yellow leaves and poor growth. Blueberry only uses ammonium nitrogen so nitrate is unavailable.
Extension Fruit Educator Michigan State University Extension
Another example,
Title of Question: Energy Crops for Biogas Feedstock
Question: Which type of energy crop seems best suited as a feedstock for biogas production (anaerobic digestion)? I realize there are many variables, so to narrow the field, let's say the crop is to be grown in the upper Midwest on marginal soils (say reclaimed mine lands).
Response:
You have asked a question we are trying to answer. The Europeans would say the answer to your question is maize (corn). Corn produces a great deal of biogas in a high solids digester. As you know, we grow corn very well in the Upper Midwest. However, there are to many competing uses for corn, so growing it as an energy crop is not an option in my opinion. The caveat you make is growing an energy crop on marginal land. We know how to grow switchgrass in Michigan. We have established test plots now going on five years. It will grow on marginal land. I know switchgrass has been successfully grown in Illinois. I have successfully produced biogas from ensiled switchgrass. This has encouraged me to try to determine where, in the growth of the switchgrass, is the best time to harvest for maximum biogas production. As you know, the more mature a plant gets, the more lignin and cellulose content there is. Lignin and cellulose are not broken down in a digester. Feel free to contact me if you want to discuss this further.

V(E). Planned Program (Outputs)

1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	16021	48063	8604	25812

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

Year:	2014
Actual:	30

Patents listed

MICL01832: Management of Turfgrass Diseases #14/101,723 (12-10-13)& #8623111 (1/7/14); MICL02278: Molecular Genetics of Plant Defense Against Insects #2,586,048 (3.11.14); MICL02141: Molecular Insights Into Geobacter Biofilms #61/989,922 (5/7/14); #14/193,943 (2/28/14); #8729233 (5/20/14); MICL02304: Effects of nitrogen deposition on the ecology and evolution of the legum e-rhizobium mutualism #2737704 (11/19/13); #2011201768 (5/24/14); MICL01814: Elucidating the mechanisms of insect mating disruption and trapping #61/961,526 (10/17/13); #14/229,388 (3/28/14); #14/044,748 (10/2/13); #14/061,460 (10/23/14); #14/077,897 (11/12/13); #8735633 (5/27/14); #2507200 (2/12/14); #8,613,780 (12/24/13); #258051 (11/28/13); MICL02258: Biology and Management of Insects in Michigan Field Crops: #2823249 (8/6/13); MICL01806: Enhancing Potato Quality through Genetic Improvement and Variety Development: #201400226 (3/13/14); MICL02283: New Arthropod Pest Conotrols and Management Strategies for Michigan Tree Fruit Production Systems: #13/805,926 (7/18/13); MICL02166:Chemical Catalysis and Processing for Advanced Biofuels and Biochemicals : #13/805,926 (7/18/13); MICL01810: Genetic Improvement of Strawberries and Blueberries: #13/998,453 (11/1/13); #13/998,457 (11/1/13); #13519002 (12/17/13); MICL02265:Genetic and Genomic-Based Approaches for Exploring Biology and Evolution in the Solanaceae Family :#14/130,890 (4/11/14); MICL02133 : The convergence and activation of abiotic and biotic stress signaling in plants #14/384,094(9/9/14); MICL02299: Role of the Plant Secretory Pathway in Growth and Response to Stress #61/842,077 (7/2/13); #PCT/US2014/044662 (6/27/14); MICL01779: The Physiology and Biochemistry of Herbicide Action, Selectivity, and Degradation #61/949,475 (3/7/14); MICL02315: Exploring Sporulation and Spore Dispersal in Fungal Pathogens: #62/008,673 (6/6/14)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2014	Extension	Research	Total
Actual	1	56	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research projects on plant sciences.

Year	Actual
2014	83

Output #2

Output Measure

- Number of adult participants trained in plant management systems.

Year	Actual
2014	14965

Output #3

Output Measure

- Number of youth participants trained in plant management systems.

Year	Actual
2014	8604

Output #4

Output Measure

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

Year	Actual
2014	1056

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
2014	951

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Integrated pest management (IPM) offers agriculture a sustainable approach to deal with evolving pest challenges such as new invasive species, climate change, and pesticide resistance. An advisory group of farmers and representatives of the target audience helped develop the content to ensure a relevant curriculum and well attended program.

What has been done
One example is the IPM Academy that is a two-day professional development program covering fundamentals of pest management and identifying resources and technology for sustainable agriculture practitioners. In 2014, the program focused on training sustainable agriculture educators and advisors from public and private sectors. The targeted audience included crop consultants, Michigan Department of Agriculture and Rural Development personnel, Natural Resource Conservation Service employees, chemical representatives, and early-adopters from Michigan and surrounding states.

Results
Over 100 participants attended the training with participants planned to utilize, expand or improve your use of any of the following IPM practices based on the IPM Academy:
- 77% (n=43) Access MSU IPM resources online
- 79% (n=44) Scouting for insects and diseases
- 71% (n=40) Scouting for beneficial insects
- 50% (n=28) Referencing weather modeling to make management decisions (e.g. Enviroweather)
- 54% (n=30) Only treating for pests when the economic threshold is reached, as applicable
- 54% (n=30) Supporting beneficial insect habitat to promote pest control via natural enemies
- 55% (n=31) Selection of pest resistant varieties or cultivars

- 45% (n=25) Alternative weed control strategies (e.g., cultivation)
- 52% (n=29) Alternative ground cover management (e.g., cover cropping)
- 34% (n=19) Sanitation practices (removal of inoculum, sterilizing implements etc.)
- 50% (n=28) Protecting native pollinators (mowing before spraying, spraying at night, etc.)
- 61% (n=34) Soil or tissue to make nutrient management decisions
- 68% (n=38) MSU information and management practices related to invasive pest management

Evaluation results found over 30,000 acres were committed to change as a result of this initiative.

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
2014	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
A laboratory vermicomposting feeding trial was conducted using plastic trays containing 300 grams of worms in bedding. Six feedstocks covered with leafmold included: 1) pulped pineapple skin, 2)pulped melon rind, 3) pulped carrot peels and carrots, 4) pulped onion skins and spoiled onions, 5) coffee grounds, 6) a mixture of the five feedstocks, and 7) only leaf mold were added twice per week for five weeks followed by three weeks of no additional feeding. The final vermicompost pH, EC,
nutrient content and biological diversity were determined. Worm populations remained stable in all feedstocks. Onions have previously been reported as detrimental to worm populations.

A total of 20 related outreach presentations to farmers, urban agriculture practitioners and composters were made in Michigan and nationally with an emphasis on high tunnel soil fertility and health management, organic transplant fertility management, and compost and vermicompost production and use. Printed handouts were distributed at most events and are available at the PI website: www.hrt.msu.edu/john-biernbaum/pg4

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Diseases 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
2014	12

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
A new effort was initiated in March of 2014 to develop: (1) a communications strategy for informing consumers about the safety of garden center plants to bees, (2) a method for identifying nursery production practices and landscape maintenance practices that could be harmful to pollinators, (3) a set of alternative pest management practices for greenhouse and nursery growers that are emphasize safety to bees and other pollinators after plants are sold in garden centers, and (4) a set of experiments designed to determine the hazard of imidacloprid soil drenches to pollinators, using bumble bees as the test species.

The insect and arthropod collections of the A.J. Cook Arthropod Research Collection at Michigan State University contains over 1.1 million pinned and labeled specimens. In addition, the collection contains specimens in 114,000 vials and 47,000 on slides. Approximately a third of the specimens are from Michigan with many historically important specimens dating to the 1870's. There are extensive national and international holdings, including significant South American and Mexican material for Lepidoptera, Hymenoptera and Coleoptera. The ARC provides data directly to visiting scientists, in form of specimen loans, and responds to data requests. ARC also supports the MSU Bug House, 4-H activities, MSU Ag-Expo and other outreach and extension events on and off campus with insect displays, and staff knowledgeable in insect natural history. Hence, this collection is used by national and international research scientist, supports agricultural, forestry, ornamental plant industries within the state, and helps to educate the general public from children to adults. In general, bark beetles function ecologically as decomposers of wood. However, some aggressive species and, to a lesser extent, benign species kill live trees, especially during periods of environmental stress. These pests cause severe economic and ecological losses, which often equates to millions of dollars. However, efforts to study and/or control this group are

hampered by a lack of taxonomic knowledge. Hence the PI's current taxonomic research of tropical bark beetles increases the knowledge of species diversity, the relationships among the species, and results in better means for their identification. Other scientists and diagnosticians use these results to improve surveys for potential pests. In addition, the PI educates national and international technicians, undergraduates, and graduate students in the identification and systematics of bark beetles. Thereby, perpetuating knowledge of these beetles through space and time. The PI participates annually in the survey and taxonomy of exotic and pestiferous bark beetles provides for the earlier detection and rapid response of potential exotic bark beetle pests. For 2013-2014, several thousand specimens collected in Florida, Guam, Illinois, Pennsylvania, and Puerto Rico were identified. Three species new to Puerto Rico were detected. Success with this survey resulted continuous US- Forest
Service funding at MSU since 2007. In addition, the PI improved the ability to identify North American Scolytus species through the development of new taxonomic expertise, new identification methods and the improvement of taxonomic understanding of these beetles.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
212	Diseases 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
2014	13

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
Ongoing research has demonstrated potential tradeoffs between soil and weed management objectives associated with tillage and cover crop practices. For example, reductions in tillage in vegetable cropping systems has been observed to result in increases in perennial weed species such as horsenettle, and shifts in weed communities towards winter annual and grass species. Adjustments in weed management practices to address these challenges will be necessary to facilitate greater adoption of reduced tillage. Towards that end, we continue to work on developing integrated weed management systems for reduced tillage production practices which integrate chemical, biological and mechanical methods. For example, we have initiated a new study in 2014 to examine the efficacy of various "in-row" cultivation tools including torsion-weeders, finger-weeders and flex tine cultivators which may provide growers with options?other than increased herbicide use?for addressing weed management challenges.

Testing of pest control products has been ongoing in the past year in laboratory and field settings, and these have been used to inform our recommendations to growers. This information has also informed our input to US-EPA regarding pesticide registrations in response to the urgent need to control spotted wing Drosophila. We have published results on projects to evaluate the response of beneficial insects to habitat manipulation, with important findings of increased blueberry yield adjacent to these wildflower plantings. On-farm demonstrations of programs have provided venues for growers and extension educators to see the quality of the fruit first hand, and this has a large impact on grower perception of program performance. Growers have reported excellent fruit quality where our IPM programs have been adopted appropriately. Growers are now very aware of Spotted Wing Drosophila and are using our information to guide their management of this damaging new pest. This includes information on insecticide residual activity and performance of the insecticides in laboratory and field settings.

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
2014	18

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

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
2014	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
In our recent work, we investigated the extent to which cold induction of the CBF regulon is regulated by transcription factors other than CBF1, CBF2 and CBF3, and whether freezing tolerance is dependent on a functional CBF-CRT/DRE regulatory module. To address these issues we generated transgenic lines that constitutively overexpressed a truncated version of CBF2 that had dominant negative effects on the function of the CBF-CRT/DRE regulatory module, and 11 transcription factors encoded by genes that were rapidly cold-induced in parallel with the "first-wave" CBF genes, and determined the effects that

overexpressing these proteins had on global gene expression and freezing tolerance. Our results indicate that cold regulation
of the CBF regulon involves extensive co-regulation by other first-wave transcription factors; that the low temperature regulatory network beyond the CBF pathway is complex and highly interconnected; and that the increase in freezing tolerance that occurs with cold acclimation is only partially dependent on the CBF-CRT/DRE regulatory module.

Greenhouse screening protocols revealed that leaf photosynthesis and conductance decreased earlier in response to drought stress in more drought tolerant varieties, but drought susceptible varieties maintained higher gas exchange rates under well watered conditions. When exposed to exogenously applied abscisic acid (ABA), a hormone
involved in abiotic stress signaling, drought tolerant varieties more severely decreased conductance at lower ABA concentrations. Drought tolerant varieties also accumulated more organic acids and soluble sugars when exposed to drought stress: leaf samples contained three to seven-fold more malic acid, inositol, fructose, and glucose than well watered controls. To more closely separate root and shoot influences on drought tolerances, reciprocal interspecific grafts were made between
a drought susceptible P. vulgaris variety and drought tolerant P. acutifolius. As grafted plants were exposed to increasing drought, scion identity played a greater role in early and moderate drought tolerance while root identity had a greater impact on severe drought tolerance and recovery. Overall, drought tolerant Phaseolus varieties and species take a more conservative approach to growth; their photosynthetic and conductance rates are lower under ideal conditions, and they respond more quickly to drought stress.

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
2014	13

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
In the past two years, western bean cutworm populations have declined throughout Michigan. Egg masses are difficult to find, and damage has decreased except in dry beans in the Upper Peninsula (UP) of Michigan. Thus in 2014, interest in trapping much more limited that in previous seasons. Flight began in early July and, with the cool summer, extended into September. Peak flight was difficult to determine. A recommendation was made in late August for UP dry bean producers to scout fields for pod-feeding to determine the need for treatment; spraying was suggested only for these producers, and not for dry bean
growers elsewhere in the state. Information on actual damage this season is not yet available to determine if the spray recommendation was correct, as harvest is ongoing. On the educational side, the Handy Bt Trait Table, the regional extension bulletin which keeps track of the commercially available Bt traits in corn, was revised in April 2014. The table was provided gratis upon request for use by other universities and agribusinesses, and posted electronically. Another pest in corn, the western corn rootworm, was targeted in 2014 for early detection of unexplained damage to Bt corn, as potential resistance
was identified in central Michigan in 2013. Sixteen extension talks and a webinar around the state discussed Bt resistance and encouraged people to report field problems. A special grower meeting was held in the county where potential resistance was found in 2013. As a result, several of the fields with potential resistance were rotated out of corn in 2014. The PI was the lead author of a white paper contrasting rootworm Bt resistance in the eastern corn belt, the so-called 'fringe', with the current main Bt resistance area in the Midwest. This white paper was submitted as a public comment to an EPA Scientific Advisory Panel examining rootworm resistance monitoring. The paper was acknowledged by the Panel members in their final report, and it informed their

recommendations to EPA about how resistance should be monitored, reported, and handled in the east versus the Midwestern corn belt. Spring weather conditions were such that corn was planted late and field were very wet. Rootworm populations were thus very low in the potential resistance area in early August, and no new problem fields were reported as of September. Soybean aphid populations were negligible during the field season, except in a limited number of late-planted or potassium deficient fields at the end of August. Extension education was done in mid to later August to reiterate soybean aphid threshold values, explain why only certain fields were infested, and recommend spray applications only to the locations where needed. Aphid suction traps running during the season detected a late fall flight, and aphids were confirmed on buckthorn in late September. As of the writing of this report, an overwintering egg population has not been found. Discovery of, and studies on, aphid-resistant germplasm continue in cooperation with the MSU soybean breeding program. The PI is responsible for doing the field collections to establish aphid colonies to use in experimental infestations of the breeder's lines.

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
2014	12721

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

One example, soybean yield increases have not kept pace with those of corn, wheat and sugar

beets. On average, soybean producers are losing 1 to 2 bushels per acre due to harvest losses. Soybean producers that irrigate their beans are not satisfied with their irrigated soybean yields. In some cases, dryland yields are higher than irrigated yields. On-farm research and education may help soybean producers overcome these challenges.

What has been done
MSUE planned, promoted, conducted and evaluated three, high-profile educational programs in 2014.
- 2014 SMaRT (Soybean Management and Research Technology) Meetings (Dundee, Caro, Dowagiac and Hamilton)
- 2014 Soybean Harvest Equipment Field Day (Yale)
- Multi-state program titled "Producing High-yielding Soybean on Irrigated Coarse-textured Soils" (Shipshewana, IN)

Results
The results from follow-up surveys designed to measure and document the actual educational and financial impacts from these three programs found in the highlights below:

Evaluation results from the 2014 SMaRT Meetings (41 of 157 responded) indicated:

-83% said that they utilized the information they learned at the programs on their farms in 2014.
-Twenty three (23) producers indicated that they actually earned additional money in 2014 by implementing the new information they learned at the programs.
-The average amount of additional income realized by implementing the new information was $13.40 per acre. Because the new information was implemented on 5,338 acres, the actual financial impact of the programs was $71,529 in 2014 alone.
-The participants also provided specific changes they made and listed soybean topics they wanted to learn more about.

Evaluation results (44 of 163 farmers)fromthe Producing High-yielding Soybean on Irrigated Coarse-textured Soils indicated:

-75% said that they utilized the information they learned during the 2014 growing season.
-Twenty three (23) producers said they actually earned additional money by implementing the new information they learned at the program.
-The average amount of additional income was $13.15 per acre applied to 27,073 acres, producing an actual financial impact of $356,045 in 2014 alone.

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
2014	4

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: help define management strategies that address shifts in weed populations; understand the degree to which weeds affect crop establishment and production in traditional and emerging cropping systems; identify effective practices for weed control in annual and perennial horticultural crops; determine the mode of action and basis for selectivity and fate of new or potentially new herbicides for weed control in Michigan; and identify the fundamental factors in cultural and chemical weed control, weed composition and weed life cycles.

Results
As a result of our research, new labels were approved for several herbicide uses for fruit and vegetable crops. Linuron was
labeled for celeriac, cilantro, dill, horseradish, parsley, peas, rhubarb, and edamame. The fomesafen label was expanded to
include edamame, pea, pepper, tomato, pumpkin, and squash. The pendimethalin label was expanded to include green onions, and a separate state label allows a double rate on high-organic soils. S-metolachor was labeled for edamame. Prometryn was labeled for celeriac, okra,

parsley, rhubarb, and dill. Clomazone was labeled for banana pepper with a state label. The oxyfluorfen onion label
was modified for use in Michigan at higher rates at the onion one-leaf stage. Halosulfuron was labeled for caneberry and blueberry. Quinclorac was labeled for cranberry and rhubarb. Imazosulfuron was labeled for nutsedge control in pepper and tomato. Carfentrazone was labeled for hops. Sulfentrazone was labeled for use in blueberry, caneberry, and grape. Growers have adopted these new herbicide uses rapidly. Onion growers were able to prevent serious yield loss from ladysthumb
(Polygonum persicaria) competition by use of oxyfluorfen at the onion one-leaf stage. This label increased grower returns by over $1 million as a result of increased yield. Linuron and prometryn labels for dill, cilantro, and parsley resulted in large reductions in hand labor for weed control and greater yields and profits. The clomazone label for banana pepper resulted in a 10-20% yield enhancement and reduced labor costs.

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
2014	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: examine methods and problems associated with controlling disease in agriculture; gain a strategic understanding of the complexity of nematode problems and necessary disciplinary interactions; develop new, safer methods of insect control by using baculovirus biotechnology to either improve the insecticidal properties of baculoviruses or as a tool for designing safer chemical insecticides; to develop, assess and deliver effective IPM programs in cherry, apple, peach and some row crop conventional and organic commodities in the Upper Midwest; and to employ ecological and evolutionary perspectives to understand the dynamics of plant disease

Results

The Arthropod Pesticide Resistance Database has received an increasing number of visitors of which more than half are new on a monthly basis. The database itself is also growing: roughly 1,800 new cases of resistance have been reported worldwide during the past year, sourced from more than 80 scientific articles. Each case of resistance in the database contains critical information such as the species involved, active ingredient of resistance, the origin of the resistance (field or
lab selected), and location of resistance including country, state/province, city, and latitude and longitude coordinates, if
published. Each case entry also houses information pertaining to the bioassay used to determine resistance, including doses,life stage of arthropod, method, and date of test. The information contained in the database is accessible to anyone with internet access, and new cases can be submitted by authorized users. A user may become authorized by applying online,and the cases that users submit must go through a peer-reviewed submission process before they are published to the
database.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
206	Basic Plant Biology
212	Diseases 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
2014	7

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: improve control over quality loss in horticultural produce; evaluate turfgrass species and mixes for their adaptation to athletic field turf and to assess the effects of cultural practices;improve the environmental sustainability of the Michigan landscape tree industry by optimizing water and nutrient inputs and determining the utility and potential impacts of organic fertilizers;
investigate nitrogen fate in turfgrass; evaluate several perennial semi-aquatic or aquatic plants for use in the phytoremediation of nursery runoff water; and to develop protocols that growers and retailers can use to produce and profitably sell perennials as new floriculture crops while

Results
Plant performance in coir and pulp alternative containers were compared with standard HDPE containers. Water use, EC and pH of substrates was determined. Container physical properties were determined. Plant growth was not different between container types when irrigated based on water use. Water use was higher for coir and pulp containers, due to porous side walls, than HDPE containers.

we investigated the effects of high-intensity blue (B) light, alone or when added to R and FR light, on flowering and growth of several long- and short-day plants including corepsis, petunia, rudbeckia, and chrysanthemum. Plants were grown in a greenhouse under a 9-hour natural short day with or without 5.5-hour day-extension and/or 4-hour night-interruption lighting from LEDs. Blue light was delivered at three intensities, with or without R+W+FR light. Blue light alone at the highest intensity created long days in all crops as effectively as low-intensity R+W+FR light. There were some height differences among lighting treatments in some crops but not others. We conclude that night-interruption lighting with high-intensity B light, alone and when added to R and FR light, can regulate flowering of a wide range of photoperiodic crops.

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 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	1

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

Results
The third year of pruning treatments was implemented in a study in managing canopy volume in tart cherry for high density orchard plantations. Treatments were imposed on tart trees in two plots located at Oxley's Orchard, Marcellus and at the Northwest Research and Extension Center. Two rows of Montmorency trees spaced at 6 X 19 feet were pruned twice in 2014 on April 29 and June 26 (45 days post bloom) at the Oxley Orchard. Trees were topped and hedged on the sides according to 4 different canopy and 1 root pruning (bloom) treatments compared to control to force laterals and begin a process of developing a narrow hedge. Hedging was accomplished using hand-held electric-powered hedging shears. Canopies of treated trees were smaller and more compact which readily accommodated the harvester at Oxley Orchard. Fruit was harvested on July 11 using the owners Korvan (Oxbo) 9000 berry harvester per tree. Data analysis not completed as of this reporting time. The crop was abnormally small, at 10-15% due to a winter freeze episode. The harvester was successful in removing all fruit with little canopy or fruit

damage, equally, while moving at 1.5 miles per hour. At the Northwest Research Center, the pruning treatments were established on dormant trees of 3 compact scion varieties compared to Montmorency which had been planted in Spring 2011 at a spacing of 4.9 X 13.1 feet. Pruning treatments were control, root pruning (bloom), winter hedging cuts and hedging cuts during the summer on June 7 (45 days post bloom). Hedging was accomplished using hand-held electric-powered hedging shears. A summer hedging treatment was imposed at both locations. Fruit was harvested at Oxley Farms by machine on July 11 and by hand at the NWHRC on July 28. The most productive variety and treatment in 2014 was Montmorency on Mahaleb control at over 18 pounds per tree. This variety and treatment has reached its maximum space and volume allowed by a berry harvester (5 x 8 feet tunnel dimension) and may not be harvestable in 2015 using a proposed berry harvester. Montmorency in the summer hedge treatment averaged 12 pounds per tree with less canopy volume (data currently being collected). Guard trees of Montmorency on the MSU rootstocks Cass and Clinton surpassed 16 pounds per tree but with canopy volumes estimated at less than 50% of trees propagated on the standard commercial rootstock, Mahaleb. Root pruning at bloom reduced canopy volume without sacrificing crop demonstrating future potential as
an alternative approach to maintaining a compact canopy. Currently, we have three early-adopter growers amounting to 45-50 acres planted since spring 2011 in Michigan. The Michigan cherry industry is planning to support future work as this approach will require less labor, improved fruit quality and improve profitability.

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 2013-2014 fiscal year, ABR and MSUE was able to start rebuilding some of its resources after several years of either flat or funding cuts at both the state and federal levels. ABR was able to **fill voids in its research and support teams by hiring quality, skilled people for a variety of positions ranging from farm managers and grant coordinators to faculty and research technicians**. **Much needed equipment and infrastructure updates were also conducted at many on-campus and outlying research facilities**, helping to keep operations to full capacity. In 2014, ABR and Project GREEEN funds helped bridge operating budget gaps at five of the 13 outlying research centers, enabling the repairs of equipment and several buildings. Together, the organizations look to re-invigorate the MSUE presence at the 13 outlying research centers throughout the

state.

The **ongoing economic challenges** faced by Michigan continue to affect this planned program area. Consequences have included fewer new hires, delaying the award of new financial obligations, reducing levels of continued funding, and renegotiating or reducing the current scope of assistance through formula funds or block grants. Specifically, a 15 percent decreases in state funding FY2011-2012 coupled with a flat federal funding line for the following two years resulted in the elimination of 72 Extension educator positions across 83 counties, 22 academic and faculty positions on campus and 15 support staff. Administrative positions were reduced from 45 to 19 FTEs. Impacts on ABR came largely in the form of reductions in research infrastructure support. Investments in facility maintenance and equipment were postponed in an effort to avoid eliminating more than 45 research positions (faculty, support staff and graduate assistants) and one research facility had to be closed in light of the reductions. There were also fewer funds to seed research on emerging issues.

Recent **extreme weather events** also caused extensive hardship to the agriculture industry. The spring 2012 ranks among the most destructive weather periods in Michigan fruit production history, with crop losses valued at more than $500 million. Peach production suffered a 95 percent loss; tart cherry, a 90 percent crop loss; apple production, an 88 percent loss; and grapes, an 85 percent loss. The summer 2012 brought the worst drought in Michigan since 1988 with many crops suffering substantial losses.
And the winter of 2013-14 brought a series of bitterly cold air masses rolled down from the Arctic, through Canada and into Michigan. The period between November 2013 and February 2014 was the coldest in Michigan since 1911 and among the five coldest periods on record in the state.

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

Research
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.
Extension
Another example of evaluation for Extension in this area include:
Issue (who cares and why)?
Friends of the Detroit River and partners secured a grant for $471,079 to conduct a comprehensive invasive species control and outreach plan for Belle Isle. This project will conduct a comprehensive aquatic invasive species control and outreach program on Belle Isle, an historic island park and significant recreation area in the Detroit River. Youth-based

employment groups and interested public will engage in invasive species control and habitat restoration actions to protect the island's diverse ecosystem and the two recent Great Lakes Restoration Initiative funded habitat restoration projects. A Science and Education Advisory Board will also oversee the development of Aquatic Invasive Species outreach/education exhibits and programming on the island focused on a suite of aquatic invasive species threatening the Detroit River system and the Great Lakes.
Belle Isle is prominently positioned at the "Gateway" to the Detroit River. Here, the river's water quality is at its best, clear and fast-flowing from Lake St. Clair. The islands rich diversity of plants associated with its unique, 200-acre, wet mesic flatwood forest and penetrating canals provide a haven for migratory and local birds and an important nursery habitat for larval fish species. However invasive aquatic plants are encroaching the area and pose an ominous threat.
What has been done? I assisted FDR in writing the grant and identifying project partners. I also committed to serve on the Science and Education Advisory Board and to supply the Belle Isle Aquarium and Belle Isle Nature Zoo with Michigan Sea Grant educational materials as needed for the project implementation.
Results/Impact? $471,079 grant secured for Belle Isle Aquatic Invasive Species Project
What difference did it make - public value? Public knowledge of problems and solutions associated with aquatic invasive species will be increased through the incorporation of aquatic invasive species displays at Belle Isle Aquarium and Belle Isle Nature Zoo. An aquatic invasive species management plan for the island will be developed. The plan will allow for more effective management of the invasive species and better coordination of volunteers who routinely offer their services to remove invasive species.

Key Items of Evaluation

Research
Since the early 1900s, blueberries have been commercially grown in Michigan, and today the tiny berries are big business. In 2011, the Michigan blueberry industry spanned 18,000 acres and yielded 72 million pounds of fruit valued at more than $118 million.
Few MSU plant breeders have been more successful than MSU AgBioResearch scientist **James Hancock**. A professor of horticulture and recipient of the 2014 MSU Innovation Center Technology Transfer Achievement Award for excellence in applying innovation to create real-world solutions, Hancock developed four of the world's most widely planted northern highbush blueberry varieties: Aurora, Draper, Huron and Liberty (20 million plants of these varieties have been sold), along with several other successful cultivars during the past three decades at MSU.
Working closely with U.S. Department of Agriculture blueberry breeder Arlen Draper, in honor of whom Hancock named the Draper variety, Hancock realized the need for new varieties in Michigan. In 1979, Michigan farmers were planting 30- to 60-year-old varieties such as Bluecrop, which thrives in midseason but left sizable gaps at both the beginning and the end of the growing season.
After 14 years of trials, Hancock emerged with results that exceeded his expectations: six varieties of MSU blueberries that together span the entire growing season.
Blueberry varieties developed by James Hancock

- Aurora (2004) - latest ripening season of any northern highbush
- Liberty (2004) - late-season, high yields, exceptional flavor
- Draper (2004) - midseason, high yields, unusual fruit crispness, exceptional storage life
- Huron (2012) - early-season, excellent taste
- Osorno (2014) - late midseason, exceptional fruit quality, unusual heat tolerance

- Calypso (2014) - late midseason, high yields, excellent flavor

Extension

MSUE utilizes the Institute Work Teams for planning, evaluating and reporting. Work Teams in this area found:

Institute of Agriculture and Agri-Business

- 43,762 acres adopting practices that manage risks
- 24,430 acres adopting technology or tools to manage risks
- 391,368 acres adopting practices to increase yield, improve quality, or decrease inputs
- 4,133 new acres under irrigation management
- 707 farms adopting practices that manage risks
- 139 farms adopting technology or tools to manage risks
- 200 farms adopting practices to increase yield, improve quality, or decrease inputs
- 7,084 farms adopting tools or technology to increase yield, improve quality, or decrease inputs
- 238 improved existing irrigation system
- 123 new Enviroweather users
- **Children and Youth Institute**

- 3,337 youth demonstrated the ability to apply science knowledge and problem solving, critical thinking, and decision-making life skills.
- 483 adults and teen leaders indicated the ability to apply knowledge to engage youth in experiential, inquiry based science learning.
- 1,591 youth participants indicated an increase in awareness of life skills and indicate the ability to identify the life skills acquired.
- 1,472 youth participants set a goal for their career or job.
- 1,574 youth participants increased self-awareness as it relates to future career possibilities.

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%		12%	
602	Business Management, Finance, and Taxation	30%		10%	
603	Market Economics	8%		8%	
604	Marketing and Distribution Practices	5%		9%	
605	Natural Resource and Environmental Economics	5%		14%	
606	International Trade and Development Economics	2%		11%	
608	Community Resource Planning and Development	15%		10%	
609	Economic Theory and Methods	0%		12%	
610	Domestic Policy Analysis	0%		9%	
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: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	20.7	0.0	7.0	0.0
Actual Paid	33.0	0.0	9.0	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**
1616092	0	878405	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1616092	0	888910	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	3192106	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?

All MSUE field educators and specialists are encourage to be involved in eXtension through both the Ask an Expert and Communities of Practice (CoP). A total 13.28 fte's were involved in this area of economics and marketing with 7.93 fte's funded through 3bc funds.
An example,
Title of Question: organic grain farming on hills and slopes; ability to cultivate effectively
Question: Farmer from flat Illinois moving to MI with some questions about the ability and risks with the weeding of organic grains on rolling hills (14C; 6-12 degree slopes). Questions about efficacy of tine weeding, blind cultivation, row cultivation. Thanks.
Response: Yes, cultivating will be difficult. On side hills you will have to be alert and will have to correct or compensate the side draft of the cultivator and also tractor tilt. It can be done but much more skill is required. Cultuivating side slopes is not fun. A couple of areas might be tolerable but a whole farm with steep slopes would be discouraging. Six to twelve % slope is extreme for any type of farming. You may also have to be conserned about erosion. If you have a choice you may want to consider another site. Most of the organic farmers I work with are blessed to have nearly level fields.
Another example:
Title of Question: energy efficeint greenhouses
Question: Hello, I am looking for information on grants/ loans to build a hothouse using geothermal heat and solar power. I live in Grand Traverse county, but the structure would be built on my business partners property in rural Benzie county.
Response:
I know of two grant programs available for construction of high tunnels (hoophouses). They are as follows: Natural Resources Conservation Service (NRCS). Contact the NRCS office for the county where you wish to build the structure. There are specific criteria for the grant. One such criteria is that you own the property or have control of it. NRCS personnel can explain what would qualify. Typically, this grant usually pays around 70-75% of the cost of putting up a high tunnel. It is a reimbursement program in that the individual pays the money up front and then gets reimbursed once the structure is up and inspected by the NRCS personnel.
The Michigan Economic Development Corporation (MEDC) has a grant program for doing high tunnels. I'd say Google MEDC and see if you can find it on their web site for the details.
Most high tunnels are installed with no additional heat. On placing heat in a high tunnel information is usually supplied by the high tunnel dealer or a heating contractor. Also, check the requirements of the grants to see if placing heat in a high tunnel meets requirements of the granting agency.
Another excellent resources on high tunnels is the MSU Hoophouse website. To find it, Google, MSU Hoophouse and it should come up. This website provides information from what MSU has learned at their student organic farm.
With regard to solar power, there may be grants with the Farm Service Agency (FSA) is usually located in the same building as NRCS.
If you think I can be of further help in accessing resources or finding educational information on growing in high tunnels, do not hesitate to get in contact with me. Hope this information helps.

V(E). Planned Program (Outputs)

1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	14942	44826	0	0

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

Patent Applications Submitted

Year:	2014
Actual:	16

Patents listed

MICL02276: Designing Sustainable Bioenergy Systems #2011348161 (11/18/13); #13/997,043 (8/20/13); #14/251,921 (4/4/14); #14/167,430 (1/29/14); #2650860 (9/17/13); #8,673,031 (3/18/14), #2010289797 (6/12/14), #2013205681 (4/24/14); #2010249409 (5/24/14); #2,762,985 (7/9/14); #320549 (5/28/14); #2,737,704 (11/19/13); #2011201768 (5/24/14); MICL02362: Agricultural Precision Technology Adoption, Diffusion and Impacts : #61/844,248 (7/9/13); #01PCT/US2014/045115 (7/1/14); MICL02298: Improving the Quality of Decision Making in Natural Resource Management: #62/008,673 (6/6/14)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2014	Extension	Research	Total
Actual	2	37	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

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

Year	Actual
2014	33

Output #2

Output Measure

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

Year	Actual
2014	5539

Output #3

Output Measure

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

Year	Actual
2014	654

Output #4

Output Measure

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

Year	Actual
2014	8749

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 natural resource and environmental economics.
4	Number of adult participants with increased knowledge in community resource planning and development.
5	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.
6	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.
7	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.
8	Number of research programs to develop a framework to understand and analyze domestic and international trade policies and assess their impact on Michigan.
9	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
2014	4708

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Rural communities benefit in many ways from the establishment, maintenance and success of economically and environmentally sustainable farm businesses. People interested in beginning new commercial farm businesses of any size benefit from basic information on production systems, marketing options, and business skill development.

What has been done
MSUE developed a program that provided a platform for MSUE educators to present to a new and diverse audience of beginning farmers using internet webinar technology. For several educators, this was an introduction to this kind educational delivery. Eleven 2-hour evening webinars were offered from January 20 through April 2, 2014 and a twelfth webinar was offered on October 22, 2014.

Results
Evaluation questions were included in each webinar during the series through Adobe Connect interactive ?poll pods?.

Impacts of program

Of 40 respondents, 15 (38%) indicated that the program resulted in, or contributed to , the creation of a new business

Of 38 responses, 13 (34%) indicated that the program resulted in, or contributed to, the expansion of an existing farm business.

Of the 39 respondents, 7 (18%) indicated that the program resulted in, or contributed to, the addition of a new enterprise to an existing farm business.

Of the 37 respondents, 5 (16%) indicated that the program resulted in, or contributed to, the creation of new jobs.

Of the 37 respondents, 19 (51%) indicated that the program resulted in, or contributed to, development of a new feasibility plan (formal or informal) for a farm enterprise.

Of 42 respondents, 15 (36%) indicated that the program resulted in them making more money, ranging from an increase of ?<$100? to ?$5,000+?. The median range of increase for these 15 respondents was ?$101-$500?, and the mean range of increase was ?$501-$1,000?.

What difference did it make - public value?

The program contributed to the development of new and expanded farm businesses and new jobs. People used information from the program to develop feasibility plans for proposed new farm businesses or expansions. Many participants made increased income from their farm businesses as a result of the program.

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 Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	648

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Farm women have diverse backgrounds, some which prepare women well for the responsibilities of running a farm business. Other women come into farming operations when they marry men who are farmers, or when their husband or family members die and leave them in charge. Being married to a farmer or being a woman in a male dominated business has its challenges.

Becoming an effective farm business partner is the focus of Annie?s Project. The course takes the real life experiences of an Illinois farm wife and shares them with other farm women who want to learn more about a crucial and complex business environment, their own farms. Farm women find answers, strength, and friendship in Annie?s Project. They grow in confidence, business skills, and community prestige.

What has been done

Becoming an effective farm business partner is the focus of Annie?s Project. The course takes the real life experiences of an Illinois farm wife and shares them with other farm women who want to learn more about a crucial and complex business environment, their own farms. Farm women find answers, strength, and friendship in Annie?s Project. They grow in confidence, business skills, and community prestige.

Topics covered were: (1) Balance sheets, profit and loss statements, partial budgeting, (2) Crop and business insurance (3) Business planning, (4) Price risk management, (5) Property ownership alternatives, lease agreements, (6) Estate planning and business succession, (7) USDA Farm Services Agency programs, and (8) Personality assessment and family communications. Learning sessions included presentations by business professionals and MSU Extension educators and time for discussion.

Sponsorship was provided by Chemical Bank, ChoiceOne Bank, Farm Bureau Insurance-Landheer Agency, GreenStone Farm Credit Services, North Central Co-op, and Shelby State Bank.

Results

All attendees completed pre- and post-class written surveys to measure their risk management knowledge in the areas of financial, human resource, legal and production. All of these factors are directly related to BM-A3-5 Farmers/entrepreneurs utilize additional risk management tools from the AABI plan of work.

Depending on the topic, knowledge level increased 37.5% to 76.5% during their participation in the Annie?s Project.

Top areas changed:

44.7% increased their knowledge on finances
43.5% increased their knowledge on components of a balance sheet
59.5% increased their knowledge on how a lender evaluates a borrower
49.3% increased their knowledge on their insurance needs
65.4% increased their knowledge regarding forms of property ownership
76.5% increased their knowledge regarding estate plans
37.5% increased their knowledge regarding how production insurance works
46.7% increased their knowledge regarding how revenue insurance works

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 natural resource and environmental economics.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example, is water quality is a major issue in Michigan. One of the causes of pollutions failing septic systems. Most homeowners do not know to maintain and care their septic system if they even know they have one. Needed to help both commercial and home owners address this issue through septic system education. In addition, property values in Michigan has dropped significantly and water quality issues can have major impact on values, businesses and communities.

What has been done
MSUE facilitated first Commercial Onsite Wastewater System training for installers, designers and managers in Michigan. Septic system presentation was given at Inland Lakes Conference. In addition, partnered with Macomb Health Dept. to conduct homeowner septic and well use and maintenance workshops.

Results
Through these commercial and homeowner educational programs gained knowledgeable about how to use and safeguard their system, what the trouble signs are and steps to correct a problem. As more people understand and take steps to safeguard their wastewater systems, water quality will continue to improve throughout the state. In turn healthier communities will help economic growth.

4. Associated Knowledge Areas

KA Code	Knowledge Area
605	Natural Resource and Environmental Economics

Outcome #4

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
2014	7437

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example in this area, cooperative are needed to expand the dwindling network of family-owned farmers that contribute to a healthy and economically viable local farming community making up an important part of Michigan?s agricultural industry.

What has been done
With the help of Michigan State University Extension and the MSU Product Center this targeted need was addressed through Farmers on the Move (FOTM). This cooperative consists of Hispanic farmers that incorporated in June of 2009 to create a quality retail brand of fresh blueberries and vegetables for the Michigan and Midwest markets. The objectives are to provide a reliable supply of quality products year after year. The members work collectively to produce and package blueberries and vegetables. Together they process, package, deliver and share marketing expenses. Working together enables them to supply their product more efficiently and competitively, so as to realize greater profitability. Sales began in 2011.

Results
FOTM provided sustainable business growth by continuing to build a framework that fueled farmer?s entrepreneurial spirit. Additionally, the cooperative provided and coordinated trainings and educational resources to the Southwest Michigan Hispanic agricultural community. Some of the areas covered include; cultural techniques, pesticide application license class room work, generally accepted agricultural practices, and cooperative procedural activities. The number of Hispanic farms continued to increase. FOTM currently has 14 members with farms from 5 to 50 acres. Expansion of the member base with additional market knowledge should allow for sales numbers to grow. New marketing opportunities include ready to serve portion packing of blueberries and hoop houses to extend the seasonal offerings. FOTM worked closely with the Michigan State University Product Center during its formation and growth and utilized resources through the USDA Rural Cooperative Development Program.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development

Outcome #5

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
2014	16

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; and sustainable bioenergy systems.

Results

researchers who are utilizing three process based crop simulation models to identify and examine the impacts of climate on corn production in the Midwest over the past century. The 12-state region accounts for more than 80 percent of U.S. corn production and 25 percent of global output. It is part of the Useful to Useable (U2U)
Project, a U.S. Department of Agriculture National Institute of Food and Agriculture project seeking to improve the resilience and profitability of farming operations in the region amid climate variability and change.

In the work carried out at MSU, the process-based CERES (Crop Environment Resource Synthesis) -Maize crop model was used to simulate the impacts of weather and climate on corn production systems. Model validation was carried out with individual plot and county observations. The model was run with weather data for representative soils and cultivars from 1981 to 2012 to examine spatial and temporal yield variability within the region.

Another project has positively impacted decisionmaking concerning water resources, land use, and ecosystem management. These impacts will help resource beneficiaires and managers in the US and abroad improve the use, conservation, and quality of water and water-related resources.

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 #6

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
2014	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Research that enhances knowledge and informs risk analysis and management strategies and tactics related to the causes and effects of price, yield, and revenue risk in production agriculture and the costs of alternative strategies is critical to the long-term sustainability of the agrifood industry.

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; and to improve the quality of natural resource management.

Results
A project evaluating the farm capital structure investment choices was completed (paper published). This research developed a unified theoretical framework that explains farm capital structure choice. The framework accommodates different credit access scenarios and heterogeneous risk profiles of farm borrowers. It recognizes that the costs of capital are endogenously determined, reflecting the degree of credit risk and accessibility to credit markets. Based on the proposed model and predicted outcomes the paper empirically tests the impacts of different factors on capital structure choice. Results show that
the determinants of capital structure have varying effects at different ranges of leverage. The analysis integrates credit risk models and accommodates endogenous cost of capital, providing a comprehensive framework for studying farm capital structure choice and its determinants. The results provide insights that could help policy makers and lenders develop effective instruments to manage, monitor, and influence the financial leverage of farms at different quantities of debt ratio.
Another project focused on the risks associated with growth in biofuels (paper published). Recent expansions in biofuel production have led to concerns about an emerging new relationship between energy prices and the prices of agricultural feedstock for
biofuel. This research provides new econometric evidence on this relationship using common trend-common cycle decompositions to estimate long-run and short-run co-movement across various energy and agricultural prices. The paper also tests for the presence of regime changes that may alter the relationship between energy and agricultural feedstock prices under certain conditions. We find that co-movements between energy and agricultural feedstock prices tend to dissipate in the long-run, which has important risk implications for biofuel and food policy.

This past year,effort and resource were spent to develop and maintain the State of Michigan local government web portal and fiscal data management system. The portal also offers open access

data downloading, which has improved access to information and therefore accountability and transparency of local government in Michigan. The portal has been an effective tool in helping meet Governor's initiative to increase accessibility of government information for citizens. The portal is now
used to download detailed financial information into an Excel-based Citizen's Guide report developed by the Governor's office. The database facilitates transparency, and does it in a way that saves hundreds of hours of time in local government offices throughout the state every year. The portal also saves Treasury officials hundreds of hours every year by streamlining the data management process. It is now much easier for Treasury to respond to information/data requests by administration
and legislators. In 2014, Treasury granted MSU another $15,000 contract to further develop the portal. This research hit both the outreach and research aspects of the MSU mission: An article on the topic is forthcoming in Public Finance Review.

Research continues to receive attention from the media and peers as evidence of being cited in prominent media outlets such as the Detroit News, the Christian Science Monitor, and Colorado Public Radio. According to Google Scholar this research has now been cited more than 1,600 times in the academic literature.

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 #7

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
2014	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: study issues related to the management of human resources and "green" business practices in commercial recreation and tourism; profile and characterize consumers and markets for eco-friendly products.

Results
In 2014, researchers predict tourism spending, as measured by hotel and motel tax receipts, will increase 4.5 percent over 2013 levels. Nationally, leisure travel is growing at a higher rate than business travel, and tourists are increasingly searching for one-of-a-kind experiences instead of chain restaurants and hotels.

Tourism spending was strong in 2013 despite temperatures 9 percent cooler than in 2012. Helping the cause were lower gas prices (down 3 percent from 2012) and positive news coverage, such as Mackinaw City ranking as the top tourist town for families and Grand Rapids being voted Beer City USA for the second consecutive year in 2013.

Researchers see many benefits to the Pure Michigan travel campaign, including attracting out-of-state visitors, who tend to stay longer and spend more than Michiganders. A national trend showing an increase in people wanting to do multi-destination vacations also bodes well for Michigan.

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 #8

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
2014	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.

Results
During the reporting period, researchers worked on potato value chains in China, Indonesia, India, and Myanmar, mango value chains in Indonesia, watermelon value chain in Myanmar, and changes in food consumption pertaining to fruits and vegetables compared with other products in Vietnam, Indonesia, and Bangladesh. the findings from these studies are in reports and articles drafted and under preparation for submission to journals in late 2014 and early 2015. Researchers have distributed widely to individuals from the target audiences the drafts of these works in progress. Researchers have also made two horticulture-product related publications (articles) in the period, one on Asian food system transformation (including fruits and vegetables), and one on potato cold storage in India.

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 Economics
610	Domestic Policy Analysis

611 Foreign Policy and Programs

Outcome #9

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
2014	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The natural beauty and outstanding recreational opportunities provided by Michigan draw more than one million visitors a year. Improving ecological conditions and fisheries has the potential to enhance economic and recreational benefits. For this reason, it is important for natural resources and wildlife managers to understand the recreational demands and economic benefits stemming from these important resources in order to wisely protect, sustain and market them.

What has been done
Research to: develop and extend economic models for estimating consumer preferences and the demand for, and value of, recreational fisheries and wildlife resources; and to study issues related to the management of human resources in a commercial recreation and tourism context.

Results
Activities 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 location choices 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.

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 2013-2014 fiscal year, ABR and MSUE was able to start rebuilding some of its resources after several years of either flat or funding cuts at both the state and federal levels. ABR was able to **fill voids in its research and support teams by hiring quality, skilled people for a variety of positions ranging from farm managers and grant coordinators to faculty and research technicians**. **Much needed equipment and infrastructure updates were also conducted at many on-campus and outlying research facilities**, helping to keep operations to full capacity. In 2014, ABR and Project GREEEN funds helped bridge operating budget gaps at five of the 13 outlying research centers, enabling the repairs of equipment and several buildings. Together, the organizations look to re-invigorate the MSUE presence at the 13 outlying research centers throughout the state.

The **ongoing economic challenges** faced by Michigan continue to affect this planned program area. Consequences have included fewer new hires, delaying the award of new financial obligations, reducing levels of continued funding, and renegotiating or reducing the current scope of assistance through formula funds or block grants. Specifically, a 15 percent decreases in state funding FY2011-2012 coupled with a flat federal funding line for the following two years resulted in the elimination of 72 Extension educator positions across 83 counties, 22 academic and faculty positions on campus and 15 support staff. Administrative positions were reduced from 45 to 19 FTEs. Impacts on ABR came largely in the form of reductions in research infrastructure support. Investments in facility maintenance and equipment were postponed in an effort to avoid eliminating more than 45 research positions (faculty, support staff and graduate assistants) and one research facility had to be closed in light of the reductions. There were also fewer funds to seed research on emerging issues.

Recent **extreme weather events** also caused extensive hardship to the agriculture industry. The spring 2012 ranks among the most destructive weather periods in Michigan fruit production history, with crop losses valued at more than $500 million. Peach production suffered a 95 percent loss; tart cherry, a 90 percent crop loss; apple production, an 88 percent loss; and grapes, an 85 percent loss. The summer 2012 brought the worst drought

in Michigan since 1988 with many crops suffering substantial losses.
And the winter of 2013-14 brought a series of bitterly cold air masses rolled down from the Arctic, through Canada and into Michigan. The period between November 2013 and February 2014 was the coldest in Michigan since 1911 and among the five coldest periods on record in the state.

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

Research
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.
Extension
An example,
Issue (who cares and why)? The Michigan winery industry is making a significant impact and is still growing. The production of wine grapes is a key feature of the industry and is complicated and costly.
What has been done?
A Wine Grape Establishment Conference and optional Informational Pre-conference was held January 21 and 22, 2014, at locations in Novi and Traverse City, Michigan by Michigan State University Extension using a hybrid video conference format. Viticulture Enology Science Technology Alliance was a co-sponsor.
Results/Impact?
There were 32 participants in the main conference and 21 in the pre-conference. There were 23 in-class evaluations completed (72% rate).
When queried as to why they participated, 100% wanted to understand the technical aspects of starting a winery. Other reasons for attending the conference included networking with other growers, research for a possible vineyard, understanding the Michigan industry, understand business and financial planning, obtain take-home resources, and find out about marketing wine grapes were indicated by at least 78% of respondents. Wine grape-growing expertise was cited as a severe challenge by 39%.
At least 78% agreed or strongly agreed that the conference content helped them: 1) with a decision to start a vineyard; 2) better understand the Michigan grape and wine industry; 3) take advantage of educational resources; 4) decide which grape varieties to grow; 5) understand the importance of vine training; 6) understand how to purchase sound planting stock; 7) utilize the site preparation, and planting guidelines; 8) plan the vineyard layout; and 9) increase knowledge of pest management.
As the result of the conference, participants indicated they will (open-ended question): 1) take their time, rethink, or slow down (5); 2) manage pests (2); 3) get more education (3); and 4) prepare.

Future investments of $400,000-1.850 MIL are planned by 18 respondents.

Another example:

Issue and Situation: The Affordable Care Act (ACA) of 2010 included an individual shared responsibility mandate that went into effect January 1, 2014. In 2012, there were more than 1.2 million uninsured residents in Michigan, most of whom had never purchased health insurance in the past. The overall goal of this project was to facilitate and coordinate Extension outreach efforts in Michigan to disseminate information and provide community education and enrollment information to targeted groups of people who were underinsured or lacked insurance; as well as people with Medicare, Medicaid, Healthy Michigan Plan or MiChild to increase their capability and access to health insurance. Due to the ACA deadline, the task of getting information to consumers in a short period of time was essential. Health insurance capability is the empowerment of individuals to choose and purchase health insurance plans appropriate for them with respect to coverage and costs, given their financial situations and external circumstances. The ACA will affect a number of farms and business. They will need to determine if they are affected by the act and if they are, then determine options and costs to the business.

Evidence of Scholarship: Our objective was to increase consumer knowledge, understanding, and confidence in the ability to purchase health insurance in the Marketplace Exchange by strategically disseminating key messages widely and broadly through a variety of educational and communication strategies. These efforts were supported by MSU's ANR Communications, Graceful Communications and county Extension Educators in Michigan. The ABBI Extension educators researched the Affordable Care Act regulations, developed a curriculum and four fact sheet publications since none existed for their small business, self-employed and farm family audiences. The GMI and HNI educators focused on individuals and families. After reviewing curriculum options these educators chose to be trained in and use the Smart Choice Health Insurance curriculum developed by the University of Maryland Extension. This curriculum is research-based and has been used exclusively by Extension in multiple states during 2013 to 2014. It includes research-based evaluation questions to measure the objectives.
Michigan was also one of twelve states chosen to receive a $90,000 NIFA USDA grant through the Center for Medicare and Medicaid in the Department of Health and Human Services (HHS) for the "Extension Outreach on the Marketplace Exchanges of the Affordable Care Act" project in fall 2013 to 2014. The objectives were:

1. Work with a collaborative network of up to 12 states to disseminate information and provide Extension outreach, education and enrollment activities on health insurance, its terminology, and new provisions for health insurance and existing programs (Medicare, Medicaid, or CHIP) and to reach 2-5% of the targeted population in each participating state.
2. Increase the percentage of individuals among targeted groups of people who demonstrate an understanding of health insurance, its terminology, and new provisions for health insurance and existing programs (Medicare, Medicaid, or CHIP) by 15-20% in Michigan.
3. Increase the percentage of individuals among the targeted population whose confidence in purchasing health insurance through the Marketplace Exchange increase by 15-20% in Michigan.
4. Increase the number of uninsured and underinsured individuals who plan to purchase health insurance through the Marketplace Exchange by 15-20% in Michigan.

Collaboration effect on outcomes: Delivery methods included in-person group presentations, multiple weekly webinars, and posting numerous news articles and educational information on two MSUE websites: ACA Roadmap and FIRM. Educators coordinated with Michigan's HHS Navigators and Certified Enrollment Counselors (CEC) to recommend residents asking for enrollment assistance to first attend an MSUE educational presentation and complete the curriculum worksheets prior to their appointment with a CEC; results were a more time efficient and effective CEC appointment. Print, social media, and other marketing efforts were directed toward MSUE staff and potential health insurance enrollees as well as state and local partners and stakeholders to drive consumer and small business participants to the presentations. Partners included Farm Bureau, chambers of commerce, local libraries, VITA sites, Michigan Works! unemployment offices, Michigan Credit Union League, AARP, primary care physicians, local health departments, county and township government associations, and American Indian- and Arab American-serving organizations. From November, 2013 to April, 2014, reports showed the following Outputs by MSU Extension staff:

- 59 direct education activities reaching 987 consumers.
- 328 one-on-one contacts by emails and phone calls to answer questions
- 7,241 materials distributed including information tables at community events
- 14,467 indirect education activities including social media posts, ACA Roadmap web page views, news articles, e-blasts, and other media.
- 854 referrals to local health insurance enrollment counselors

Demonstrated Impacts:
Smart Choice participants (n=150) pre and post surveys showed the following behavioral changes:

- Michigan consumers are confident they
  - understand health insurance terms
  - know how to estimate costs for health care
  - what questions to ask, and can find information to choose a plan
  - Michigan consumers are likely to
    - Determine which doctors and hospitals are covered
    - Understand what they would have to pay for prescription drugs, emergency department visits, and specialist visits
      - Find out if they have to meet a deductible and if unexpected costs are covered.

Farms that attended presentations were chosen for a follow-up call/email to determine any mode of action due to attending the program. All that were contacted have stated they began to institute administrative measures to collect data/information that will be needed for ACA reporting purposes. Those that have determined that they are "large" employers have begun to work to determine the cost of providing health insurance to employees vs. penalties as well as institute some general human resource management changes.

Team Impact Resulting from Working Collaboratively: The issue of health insurance literacy affected various and diverse MSUE existing audiences differently, and reached new audiences and stakeholders not familiar with MSUE. The collaborative team reached small businesses as well as consumers with messages each needed to hear. Much confusion around health insurance plans, enrollment, and the Affordable Care Act provisions was evident during the Marketplace Open Enrollment period from October 2013 to March 2014. Small and large businesses assessed their plans and costs for employee coverage. Consumers

better understood options before enrolling. Through bi-monthly conference calls and periodic email updates, Extension Educators kept in touch, shared successes and barriers, and strategized project plans. We also learned to work collaboratively with the multi-state team.

Key Items of Evaluation

Research

Weather and climate affect all facets of agriculture, and they can do so in dramatically different fashion -- what's good for one commodity can be detrimental to another. In Michigan, which boasts the second most diverse agricultural production in the United States, this conundrum translates into lots of opportunities for research. On the flip side, even experienced meteorologists such as Jeff Andresen acknowledge that there are certain limitations in the science.

"On one hand, we all know that meteorologists are the brunt of jokes, and some of them are probably justified," he said. "However, it's also important to note that the science is getting better. For example, weather forecasts are significantly more accurate than they were in past decades. There is also more known about how weather and climate influence agriculture. That's where Michigan State University (MSU) comes into play. We have a role to provide new science and other information that help reduce weather-related risk for farmers."

Andresen, a MSU geography professor and Extension specialist, has been helping Michigan farmers prepare for Mother Nature's wrath since coming to work at MSU in 1991. At that time, he was the only MSU faculty member providing meteorology expertise to agricultural producers. Faced with a steep learning curve, Andresen recalls the advice of a colleague that provided the Illinois native more familiar with corn and soybean production one of his most valuable lessons.

Extension

MSUE utilizes the Institute Work Teams for planning, evaluating and reporting. Work Teams in this area found:

Institute of Agriculture and Agri-Business

- $54,927,530 - value of product protected
- $10,112,000 - value of product gained
- $15,746,712 - value of product saved
- $19,980,560 - dollars ($) in net farm income maintained or increased
- $5,784,283 change due to yield/productivity change
- $51,989 change in $ expended on water withdrawal
- $49,049 change in $ expended on energy
- $28,660,800 - value of retained payroll

Institute of Greening

- 101 participants showed increase understanding of relevant laws and the practical impacts of those laws on their boards
- 215 participants increased their knowledge of their board's structure, functions and duties, and/or operational best practices
- 185 participants were able to identify and locate resources for quality information and/or apply that information to the solution of problems
- 66 new diversifying/expanded agri-food businesses developed as result of MSUE efforts.
- 34 GM-4-EM-A2-I1: Number of producers that report selling at local/regional markets as a result of MSUE efforts.
- 716 new vendors, farm markets, road side stands that accept Bridge Cards, Project Fresh, and participate in Double Up Food Bucks as a result of MSUE efforts.

Product Center (research and extension)

The Product Center's assistance in launching 396 known new businesses and business expansions has had the following estimated economic impacts:

- Increased annual sales: $321.9million (cumulative first year sales only)

- Value of increased investment: $322.1million

- Jobs created: 1,147; Jobs retained: 644

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	10%		10%	
302	Nutrient Utilization in Animals	10%		13%	
303	Genetic Improvement of Animals	0%		10%	
304	Animal Genome	0%		10%	
305	Animal Physiological Processes	0%		10%	
307	Animal Management Systems	45%		13%	
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	5%		11%	
605	Natural Resource and Environmental Economics	10%		5%	
806	Youth Development	10%		0%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	15.1	0.0	9.5	0.0
Actual Paid	17.0	0.0	9.6	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**
780695	0	930076	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
780695	0	941199	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	3379877	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?

All MSUE field educators and specialists are encourage to be involved in eXtension through both the Ask an Expert and Communities of Practice (CoP). A total 3.59 fte's were involved in this area of animal production with 2.58 fte's funded through 3bc funds.
An example in this area is:
Title of Question: Toxicity of Sweet Pea to Equines
Question: I purchased grass hay that contains a small amount of sweet pea vines, flowers, and seed pods. I understand the pods are toxic to equines if eaten in large quantity but is there a problem with a

small amount of dried sweet pea pods in horse hay?
Response: Hello,
I have not heard of cases where small amounts have caused problems for horses in dry hay. In researching a bit further, I came across the following link: http://www.petpoisonhelpline.com/poison/sweet-pea/

If you can easily see and remove them that might be best, not knowing what defining as small amounts, but a couple of pods likely won't hurt most horses.

Another example:
Title of Question: CL vaccine/test/treatment for goats
Question: I have recently put a goat down as she was infected with the CL bacterium. This has caused an intense bout of reading up on treatments and vaccines leading to three questions. Question one: in your opinion is there a vaccine you would recommend for goats (I am specifically looking at one offered on the Jeffers website that is specifically for goats)? Question two: is there any treatment whatsoever for CL? I am seeing some talk about using formalin (formadahyde) injected into the abcess....(while this does not cure the infection it is supposed to prevent its spread). Question three: is there a reliable test that I can have done on the rest of my herd to determine who is/is not infected?
Response: CL is very contagious. Once an abscess is open the organism can be spread. Abscesses not only open through the skin, but can open in the lungs and mammary system as well. The organism is thought to survive for years in organic material. If the animal that you had "popped" an abscess on your farm it is highly likely that it was spread in your herd.
There are vaccines available for CL. It often comes with a CD-T vaccine. There is good evidence that these vaccines work well in sheep and goats (it is the same organism that causes the disease and can spread between sheep and goats). The key to elimination of the disease is to vaccinate the young animals before they become infected. Once infected and animal will be infected for life. Also vaccination must be done annually for several years after the last abscess is seen as the organism can live for years in the environment. Kids should be raised in heat treated colostrum and pasteurized milk as the abscess can also form in the udder and be passed on that way.
As far as I know injecting the abscess with formalin is not a legal treatment for CL and this should be discussed with your herd veterinarian.
There are blood tests that can be done to test animals for CL. Just remember that once an animal is vaccinated it will test positive for CL.

An evaluation of Horses Community of Practice 101 Purchasing and Owning on-line course found from analyzing 169 surveys that:
- 96% of the participants stated the course gave them a better understanding of purchasing and owning horses?
- 64% of the participants rated the course excellent
- 88% of the participants would recommend the course

A comment stated: "Thank you for offering this online course. The information provided was very informative. Made me realize how much I did not know!"
For more information about the course, go to: http://www.extension.org/pages/9611/my-horse-university#.VRWJzi4qTP0

V(E). Planned Program (Outputs)

1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	2775	8325	58860	117720

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

Patent Applications Submitted

Year:	2014
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2014	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
2014	36

Output #2

Output Measure

- Number of adult participants trained in animal management systems.

Year	Actual
2014	2775

Output #3

Output Measure

- Number of youth participants trained in animal management systems.

Year	Actual

2014 58860

Output #4

Output Measure

- Number of adult participants trained in animal diseases.
  Not reporting on this Output for this Annual Report

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 adult participants with increased knowledge of animal diseases.
4	Number of research programs to understand the processes that control/influence reproduction at the molecular and genetic level.
5	Number of research programs to add to the understanding of various food animal genomes by improving and integrating genetic maps.
6	Number of research programs to develop and evaluate new tools and strategies to detect, prevent and control emerging and reemerging livestock and poultry diseases.
7	Number of research programs to understand the environmental fate and biological effects of vaccines, steroids and other substances fed to animals.
8	Number of research programs to develop and evaluate management/training strategies for horses to reduce injuries.
9	Number of research programs to add to the understanding of animal behavior and welfare.
10	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
2014	2702

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One example in this area, a major customer to the local Turkey Producers Co-operative informed them that although they were currently supplying them with Antibiotic Free/No Animal By-product (ABF/NAB) turkey meat for their stores, unless they could achieve Step 1 Certification for Animal Welfare through Global Animal Partnership on each of the six farms that supply birds to them, they would no longer be a supplier. This would leave the Co-operative with ABF/NAB product available for sale without a secure customer. Certainly the product could be boxed and stored in frozen cold storage, but the value of the product would go down with the extra handling and expense of boxing as well as the cost of outside cold storage and transportation of the product.

What has been done
Working with 3 farm families, each owning 2 farms requiring the audit, I went through each line on the audit (187 individual line items). Where programs were necessary, I worked with each farm to write a program. Where training documents or forms were necessary, I worked with each farm to create them. Based on the flow of the audit, a manual with all of the necessary information in it was developed for each farm.

Prior to the audit a visit was made to each farm to conduct a 'mock audit' for the day. I assumed the role of the auditor as a practice for each farm to feel comfortable with where the information the auditor was looking for was located within their program. We also toured the farms to look at the things the auditor would be looking for during the audit and assess the overall readiness of the farm for the audit.

On the day of the audit, I was either present for the entire audit (including load-out of birds on one farm through the night) or I was available on the phone for questions that came up during the audit.

As audit results were available, I worked with each farm to make necessary corrective actions and submit them for review prior to certification.

Results
Each of the six farms received their Animal Welfare Certification. The result to the farms is as follows:

Allegan County - 2 farms

Montcalm County - 2 farms

Oceana County - 2 farms

Total of 15 finisher barns, each barn capable of 3 turns per year (15 x 3 = 45 flocks)

Each flock has 10,000 poults placed (45 x 10,000 = 450,000 poults annually)

Target 85% livability (450,000 x .85 = 382,500 finished birds annually)

Average finished weight per bird is 40 pounds (450,000 x 40 = 15,300,000 pounds annually)

ABF/NAB GAP Certified flocks are paid 0.07¢ more per pound than traditional flocks (15,300,000 x 0.07 = $1,071,000.00 increase to Michigan Agriculture annually

What difference did it make - public value?

Society has an ethical concern about the quality of life experienced by farm animals - consumers want to know where their food comes from, how it is grown, and what practices are employed. It is a current trend that customers are requiring farms to become audited - not just for marketing the compliance of animal welfare standards on their packaging. Reputable third party audits help both the producer and their customer in the eyes of the consumer. Helping Michigan farmers obtain animal welfare certification keeps Michigan Agriculture on the forefront of change in animal agriculture. Becoming compliant with third party Animal Welfare standards can in some cases help farms become more profitable as was the case above.

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
2014	56101

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Youth are needing experiences that give them a real life understanding of supply and demand principles and a greater capacity to succeed in business in the future.

What has been done
One example to address this need, youth participated in a MSUE 4-H livestock auction where programming increased significantly that impacted those in the marketing projects. With new members, came new buyers and greater community understanding of MSUE 4-H programming. The kids worked to market their animals with area businesses and served on the committee to make decisions.

Results
The 2014 4-H Market Livestock sales topped $190K. 105 animals were sold at the auction. A new record was set for price/pound for a lamb at $16.50/lb. The news of the record sale made the cover of the weekly local newspaper and increased program visibility. Oceana County 4-H youth recognized the importance of a successful marketing plan and how competition can drive the prices higher.

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 adult participants with increased knowledge of animal diseases.

Not Reporting on this Outcome Measure

Outcome #4

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
2014	7

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
Researchers have identified genes in mice that appear to be important
to egg quality and discovered that oocytes may edit the paternal contribution to progeny characteristics. They are also studying environmental stressors on the early molecular development of mammal embryos and ties to conditions such as attention deficient disorder, Type 2 diabetes, obesity and asthma later in life.

Researchers have been developing a cost effective tool to analyze specific elements, called single-nucleotide polymorphisms
(SNPs), within a pig?s genetic code. They insert a sample of genetic material, such as blood or hair, into the device, called a SNP

chip. Probes then target each SNP with fluorescence technology. The probes glow different colors, denoting which SNPs are present, so the user can fully characterize an individual pig?s entire genotype. Applying the SNP chip to an entire population of pigs, such as a farm herd, enables breeders to predict the genetic value ? the number of desirable traits ? of the pigs and dramatically increase breeding
efficiency.

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 #5

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
2014	3

3c. Qualitative Outcome or Impact Statement

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

What has been done
Research to: develop methods for producers and consultants to evaluate dairy herd performance and assess trends for herd life and culling rates;develop a new set of tools and reagents to study autologous cell therapy using a new large animal model; and to develop and adapt staistical and

computational methods to link phenotypic variation to genomic variation.

Results

We have made significant progress towards achieving our goals by providing a basic understanding on how the genes Sox2 and Cdx2 regulate early differentiation in the bovine embryo. Specifically for the gene Sox2 we determine its spatial and temporal localization of the SOX2 protein, revealing that its expression starts at the 16-cell stage and then becomes restricted to the ICMs of blastocysts. To study the role of SOX2 during the early development of bovine embryos, we designed siRNA to target SOX2. We began by injecting this siRNA into zygotes; the rate at which blastocysts developed declined compared to ioninjected or scrambleinjected controls. When only one blastomere of a two-cell embryo was injected with SOX2 siRNA, we observed development
rates similar to those of controls. Daughter cells of the injected blastomere were tracked by TRITC fluorescence and found to contribute to the ICM, as select cells also lacked SOX2. Gene expression analysis revealed a decrease in SOX2 and NANOG gene expression in siRNA-injected embryos, but OCT4 expression remained unchanged. We conclude that SOX2 localizes exclusively in the ICM of bovine blastocysts, and its downregulation negatively impacts preimplantation development; however, it is still unclear as to why downregulation of SOX2 in one cell of a two-cell embryo does not affect the composition of the ICM.
For the gene Cdx2, we found that the protein was present only at the blastocyst stage. To further understand the roles of CDX2 during bovine development, we depleted CDX2 mRNA and despite a significant loss of detectable protein, embryos were able to form blastocysts at the same rate as controls. Embryos lacking CDX2 did not show abnormalities in the number of trophectoderm, and inner cell mass cells, or total cells in the blastocyst.
Expression of the developmentally important genes SOX2, POU5F1, and NANOG, or TE markers such as IFN-T and KRT18 were not affected by the reduction in CDX2 levels, nor was the localization of SOX2 and POU5F1 protein. Using a functional barrier assay, we observed that the TE epithelial layer of embryos lacking CDX2 had lost its integrity.
Our results thus indicate that CDX2 is not required for TE formation during bovine development; nevertheless, it is necessary for maintaining TE integrity.

4. Associated Knowledge Areas

KA Code	Knowledge Area
304	Animal Genome
305	Animal Physiological Processes

Outcome #6

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
2014	7

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Animal disease in the United States could seriously damage the livestock and poultry industries. For example, eradication of avian influenza in the United States following an outbreak in the mid-1980's resulted in the destruction of 17 million birds and cost taxpayers nearly $65 million. The collective effort and vigilance of researchers, livestock producers, veterinarians and state and local government officials is needed to ensure adequate disease surveillance and to provide the needed resources to prevent, respond and/or eliminate disease outbreaks.

Keeping livestock free from infectious disease has been a concern since the first sheep and goats were domesticated in Mesopotamia almost 10,000 years ago. Sick animals produce less food, pose a risk to humans that consume their meat and milk, and threaten the health of the entire herd by spreading the contagion. After struggling to fight infection by quarantine and natural remedies, livestock producers began using antibiotics in the last century to combat disease with unprecedented efficiency. Antibiotic resistance is threatening to undermine the past 70 years of progress.

What has been done
Research to: develop new interventions to reduce antimicrobial resistance when treating animals with antimicrobial drugs and to develop a new non-antibiotic treatment for mastitis in dairy cows; determine the contribution of T2SS to biofilm formation in gram-negative human and plant pathogens' better understand parasitic and mutualistic interactions in a bacteria-nematode insect association; collect and screen for bacterial strains with antagonistic properties for food borne pathogens and test their efficacy; and improve immune recognition in order to protect against or eliminate viruses and diseases such as Johne's disease.

Results
Researchers found that regularly using antibiotic-medicated milk replacers on calves plays a role in resistance levels. Milk replacers are commercial substitutes for whole milk that are commonly used to feed calves on farms because they are typically less expensive and have less risk of contamination than whole milk. Taking a sample of Michigan dairy farms, all of whom initially fed calves with antibiotic-medicated milk replacers, researchers divided them into two groups. One group continued to use the medicated replacers, and the other switched to replacers without antibiotics. They then took samples from the animals and environments of each farm over the

course of one year and found that, in the group without antibiotics, resistance had decreased.

Though the initial results looked promising, that soon changed. Those farms eventually began to experience a resurgence of resistance. Simply eliminating the use of antibiotics was not enough? new techniques would be needed. Currently, researchers are in the beginning stages of research to investigate new treatments for gastrointestinal disease in cattle that do not involve antibiotics.

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 #7

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
2014	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Michiganders are an exceptionally vulnerable population due to their chronic exposure to complex mixtures of endocrine disruptors, which include legacy environmental contaminants (e.g., dioxin, PCBs, DDT) within the Great Lakes basin. A comprehensive molecular and physiological understanding of the interactions that may occur is critical to human health. Also, vaccines, steroids, antibiotics and other substances are added to animal feed to improve growth rates by controlling parasitic and bacterial diseases. With the recent major expansion in concentrated animal feedlot operations, the potential risks from these operations must be assessed.

Much of the Western world appears on a mission to keep bacteria at bay. The increased use of antibacterial soaps and cleaning solutions has resulted in a billion-dollar industry that encourages

consumers to destroy the microscopic foes inhabiting homes and workspaces to prevent the spread of illness and disease. What often goes unmentioned is the fact that the human body is home to roughly 100 trillion microbes living on the skin and in the mouth, nose and intestines ? and not all of them are bad.

What has been done
Research to: achieve a better understanding of the impact of animal agriculture on society by integrating the risks and benefits related to economics, environmental protection and human health; develop multistage hierarchical models to facilitate greater efficiency of inference in general mixed model microarray experiments; and to identify the environmental transformations undergone by animal feed additives and determine their environmental fate.

Results
C. jejuni infections are the most common cause of bacterial gastroenteritis in Michigan and are most often acquired when people consume raw or undercooked poultry, unpasteurized milk or contaminated water. Like C. difficile, C. jejuni colonizes the gastrointestinal tract and causes intestinal inflammation resulting in vomiting and diarrhea, and, for some, the long-term complications associated with GBS. A percentage of patients experience paralysis only in their limbs; in others, the paralysis advances until they can no longer breathe on their own, forcing reliance on an iron lung or respirator for support.
MSU Researchers were the first to use a mouse model to show that C.jejuni employs this molecular mimicry. Their goal was to learn more about the factors that facilitate the intestinal inflammation and destructive autoimmune response caused by the bacterium.

They also uncovered a second important insight about C. jejuni: the bacterium can evolve inside its host in real time.

It?s widely understood that pathogens adapt to their environment by changing the genes they express through the evolutionary processes of mutation and selection, which preserve favorable genetic changes that help organisms survive. However, very little is known about how bacteria adapt during infection.

The lab made progress in exploring this area of microbiology by demonstrating that C. jejuni rapidly changes from one heritable genetic state to another in its host.

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 #8

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
2014	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: investigate ways to manipulate bone density and strength through mechanical loading to help prevent injuries to performance horses and increase the longevity of livestock; identify ways to manipulate the equine diet to optimize skeletal health and improve the overall welfare of horses; and to define the role that EHV-5 plays in the development of spontaneous equine multinodular pulmonary fibrosis.

Results
Oral supplementation of omega-3 (n-3) fatty acids (FA) may have anti-inflammatory benefits, which could improve health and performance of exercising horses. However, the effects of various sources and amounts of n-3 FA in healthy mature exercising horses have not been well documented. Thus, the objective of this study was to determine the effect of the supplementation of differing sources of dietary long-chain polyunsaturated n-3 FA on health and performance parameters of horses. The increases in the amount of omega-3 fatty acids in plasma was also accompanied by a longer stride length after supplementation and hence appeared to ease problems associated with osteoarthritis. In further work, horses received one of three diets that differed in n-3 fatty acid profiles. The results of this study indicate that mature exercising horses free from osteoarthritis do not exhibit physiological anti-inflammatory benefits when supplemented with a low dose of omega-3 fatty acids over a 21-d period. This study suggests a higher dose of DHA may need to be offered. Alternatively, if feeding DHA at an amount lower than 30 to 35 g/d,

supplementation longer than 21-d may be required to observe potential differences in plasma FA concentrations. To our knowledge, this is the first study to supplement n-3 FA in the form of DHA-rich microalgae (DRM) to exercising horses. As nothing is known about potential differences in bioavailability of a DRM source of DHA in the horse, additional research is needed with an amount greater than 28.4 g/d for a 21-d period of DHA to validate the effects of a DRM DHA source on metabolic effects of DHA in the horse.

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 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
2014	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
research focuses on mastitis, a bacteria-caused inflammation of the cow?s udder and the most common disease to afflict dairy cattle in the United States. According to the U.S. Department of Agriculture, mastitis affects 15 to 20 percent of Michigan dairy cows annually. For an average-size dairy farm of 187 cows, the disease can result in the annual loss of about 25,000 pounds of milk and an annual cost of up to $10,000 in medical treatment. Severe cases can result in even greater losses along with long-term impacts on the health, welfare and fertility of the affected animals.

Part of this research is determining when antibiotic therapy is an appropriate tactic. Mastitis is caused by a wide range of bacterial pathogens, not all of which are susceptible to antibiotics. The most common agents of mastitis, streptococci and staphylococci, respond very well to antibiotics if caught in time. Other causes, however, do not.Establishing and following protocols for the daily operations of a dairy farm, from milking procedures to administering antibiotics to preparing feedstocks, is paramount to a healthy herd.

On the basis of a survey of the concerns and practices of more than 600 producers in Michigan, Florida and Pennsylvania, the team crafted an evaluation system to develop protocols and educational materials to help veterinarians educate farm employees.

4. Associated Knowledge Areas

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

Outcome #10

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
2014	11

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 evaluated the effects of propionic acid and glycerol that have similar metabolisable energy but different routes of metabolism on feeding behavior and dry matter intake of cows in the postpartum period.
We evaluated the effects of glucose precursors with different routes of metabolism as potential treatments for ketosis with cows in the postpartum period. We completed an experiment to evaluate the relationship between feed intake and the change in hepatic acetyl CoA content. We conducted an experiment to evaluate supplementation of chromium proportionate for the first 120 days of lactation. We completed an experiment to evaluate the effect of time of chromium supplementation on production and metabolic responses of cows in early lactation. Results have been disseminated to the scientific community at professional meetings, to nutritionists and veterinarians at
nutrition and management conferences, and to dairy producers at meetings.

The development of improved grazing dairy systems for Michigan and the
upper Midwest requires the investigation of alternative strategies to refine milk production systems that are profitable and
ecologically sustainable. In the context of grazing dairies utilizing AMS, this can be achieve by the collective implementation of
forage (pasture/forage systems, irrigation), feeding (supplementation), animal (genotype, lactation) and grazing (stocking rates,
allocation) strategies that optimize the labor, use of the land base, milk production and ecosystem functions and services. This
project propose the investigation of these strategies for the optimization of dairy systems utilizing AMS in concert with grazing. Breed had marked effects on the milk performance, feed efficiency and use of robotic milking in pasture-based farms. In turn,
proper stocking rate management in concert with accurate supplementation with mixed ration was critical to managing pasture
growth rate, forage utilization and occupancy and revenue of robotic milking stalls.

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 2013-2014 fiscal year, ABR and MSUE was able to start rebuilding some of its resources after several years of either flat or funding cuts at both the state and federal levels. ABR was able to **fill voids in its research and support teams by hiring quality, skilled people for a variety of positions ranging from farm managers and grant coordinators to faculty and research technicians**. **Much needed equipment and infrastructure updates were also conducted at many on-campus and outlying research facilities**, helping to keep operations to full capacity. In 2014, ABR and Project GREEEN funds helped bridge operating budget gaps at five of the 13 outlying research centers, enabling the repairs of equipment and several buildings. Together, the organizations look to re-invigorate the MSUE presence at the 13 outlying research centers throughout the state.

The **ongoing economic challenges** faced by Michigan continue to affect this planned program area. Consequences have included fewer new hires, delaying the award of new financial obligations, reducing levels of continued funding, and renegotiating or reducing the current scope of assistance through formula funds or block grants. Specifically, a 15 percent decreases in state funding FY2011-2012 coupled with a flat federal funding line for the following two years resulted in the elimination of 72 Extension educator positions across 83 counties, 22 academic and faculty positions on campus and 15 support staff. Administrative positions were reduced from 45 to 19 FTEs. Impacts on ABR came largely in the form of reductions in research infrastructure support. Investments in facility maintenance and equipment were postponed in an effort to avoid eliminating more than 45 research positions (faculty, support staff and graduate assistants) and one research facility had to be closed in light of the reductions. There were also fewer funds to seed research on emerging issues.

Recent **extreme weather events** also caused extensive hardship to the agriculture industry. The spring 2012 ranks among the most destructive weather periods in Michigan fruit

production history, with crop losses valued at more than $500 million. Peach production suffered a 95 percent loss; tart cherry, a 90 percent crop loss; apple production, an 88 percent loss; and grapes, an 85 percent loss. The summer 2012 brought the worst drought in Michigan since 1988 with many crops suffering substantial losses.
And the winter of 2013-14 brought a series of bitterly cold air masses rolled down from the Arctic, through Canada and into Michigan. The period between November 2013 and February 2014 was the coldest in Michigan since 1911 and among the five coldest periods on record in the state.

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

Research
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.

Extension
Another example of evaluation in this area included:
Issue: Youth need to learn about basic information regarding dairy cattle that will help them in critical thinking, problem solving and caring for animals.
What was done: 4-H Exploration Days educated young people ages 11-19 and involves about 2,500 participants from all parts of Michigan. This session was designed to: teach youth about parts of the mammal eye; provide hands-on learning activities for youth through the dissection of a cow eye; and allow students to tour the MSU Dairy Teaching and Research Center to apply their knowledge of dairy cattle.
Results: Evaluation results found: 100% of the participants agreed or strongly agreed that they were more knowledgeable about animal science; 88% felt more knowledgeable about entrepreneurship and career opportunities in animal science-related fields; and 92% planned on applying the meat science knowledge and skills from the session.

Key Items of Evaluation

Research
Keeping livestock free from infectious disease has been a concern since the first sheep and goats were domesticated in Mesopotamia almost 10,000 years ago. Sick animals produce less food, pose a risk to humans that consume their meat and milk, and threaten the health of the entire herd by spreading the contagion. After struggling to fight infection by quarantine and natural remedies, livestock producers began using antibiotics in the last century to combat disease with unprecedented efficiency.
However, with antibiotic resistance threatening to undermine the past 70 years of progress, another novel set of tactics is needed to ensure food security and safety. Michigan State

University (MSU) AgBioResearch scientists from the College of Veterinary Medicine are working to develop new techniques aside from conventional antibiotics to fight and prevent diseases on the farm.

MSU associate professor of large animal clinical sciences **Bo Norby** has been studying antibiotic resistance on and off since graduate school. He began as a Ph.D. student at MSU measuring the impact of antibiotic elimination of resistance levels of bacteria in pigs raised on organic farms versus those raised on conventional farms.

John Kaneene, director of the MSU Center for Comparative Epidemiology studies the epidemiology and mechanisms of antibiotic resistance in both livestock and humans. One focus is on identifying the factors that cause resistance to form.

"By understanding the mechanisms and dynamics of antibiotic resistance, we can get a sense of the magnitude of the problem," said the MSU professor of epidemiology.

Kaneene has conducted research that found that regularly using antibiotic-medicated milk replacers on calves plays a role in resistance levels. Milk replacers are commercial substitutes for whole milk that are commonly used to feed calves on farms because they are typically less expensive and have less risk of contamination than whole milk. Taking a sample of Michigan dairy farms, all of whom initially fed calves with antibiotic-medicated milk replacers, Kaneene divided them into two groups. One group continued to use the medicated replacers, and the other switched to replacers without antibiotics. Kaneene and his team took samples from the animals and environments of each farm over the course of one year and found that, in the group without antibiotics, resistance had decreased.

Extension

MSUE utilizes the Institute Work Teams for planning, evaluating and reporting. Work Teams in this area found:

Institute of Agriculture and Agri-Business

- 35,001 animal units adopting practices that manage risks
- 707 farms adopting practices that manage risks
- 139 farms adopting technology or tools to manage risks
- 200 farms adopting practices to increase yield, improve quality, or decrease inputs
- 7,084 farms adopting tools or technology to increase yield, improve quality, or decrease inputs

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%		14%	
402	Engineering Systems and Equipment	0%		10%	
501	New and Improved Food Processing Technologies	0%		15%	
502	New and Improved Food Products	0%		15%	
503	Quality Maintenance in Storing and Marketing Food Products	0%		14%	
504	Home and Commercial Food Service	10%		0%	
511	New and Improved Non-Food Products and Processes	30%		16%	
512	Quality Maintenance in Storing and Marketing Non-Food Products	10%		0%	
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: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	3.1	0.0	6.0	0.0
Actual Paid	6.0	0.0	6.3	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**
239227	0	568380	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
239227	0	575177	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	2065480	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?

All MSUE field educators and specialists are encourage to be involved in eXtension through both the Ask an Expert and Communities of Practice (CoP). A total 5.51 fte's were involved in this area of food and non-food quality with 1.73 fte's funded through 3bc funds. Examples from Ask an Expert Questions are below:
Title of Question: biogas energy
Question:
1]What is the difference between composite gas cylinders, high pressure steel cylinders and LPG cylinders?
2] Which of the above storage facilities is recommended for packaging methane gas from biogas operations?
Response:
I called the Compressed Gas Association and also talked with several propane gas distributors in my locale. This is what I learned. The difference between composite gas cylinders, high pressure steel cylinders and LPG cylinders is in weight and use. Composite cylinders weigh less and can be used for the basic same purposes as other cylinders. One caveat to that statement is no one I spoke with had high pressure composite cylinders. However, composite cylinders (tanks) have been used to hold rocket fuel for

years. As far as use goes, LPG cylinders and composite gas cylinders are typically used in outdoor gas grills. They typically operate at a pressure of 175 psi but can go as high as 275 psi for certain uses. High pressure steel cylinders hold gases used for welding and other industrial uses. The standard high pressure cylinder is at 2,300 psi while the high volume cylinder can be as high as 6,000 psi. I do not know which of the three is best for methane utilization, however, one welding supply shop I spoke with said they sell three grades of methane - a commercial grade (93% methane), a technical grade (97% methane), and a pipeline quality grade (99% methane). They come in cylinders with a pressure ranging between 1,800-2,400 psi. Obviously you will want to remove moisture, carbon dioxide and hydrogen sulfide before charging your cylinders. You don't want to bottle biogas, you want to bottle methane.

Title of Response: COTTAGE LAW FOODS
Question: Hello, I would like to know if canned applesauce and pie filling is allowed to be sold under the cottage food law. Thank you.
Response:
Hello,
No applesauce and apple pie filling are not allowe to be sold under the cottage food law. Here is the website that will be of help to you in regards to the MI Cottage Food Law and what can be sold and what cannot. www.michigan.gov/cottagefood There is lots of useful information at this site that you will be interested in.
Another example:
Title of Question: servsafe info
Question: Hello from Washtenaw County. What us the difference between the 8 hour Servsafe class and the 16 hour one? K
Response:
Hi K -
The 16-hour ServSafe is more intensive. We go over each chapter at a slower pace, ending the second day with the exam. The 8-hour course is more of a review course, with only six hours of "class" and two hours for the exam. If one already is experienced in food service or has been certified before, the 8-hour is usually a good review.
If you have further questions, you can call your local MSU Extension office and ask for the food safety educator. They will be able to give you her/his number.

V(E). Planned Program (Outputs)

1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	7523	22569	0	0

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

Year:	2014
Actual:	23

Patents listed
MICL02290: Property Modeling and Prediction for the Bioeconomy #61/961,526 (10/17/13); #8613780 (12/24/13); #2507200 (2/12/14); #8,735,633 (5/27/14); #258051 (11/28/13);

MICL02291: Bioreactor Engineering for Gas-Intensive Fermentations to Produce Biobased Fuels and Chemicals: #14/199,714 (3/6/14); #14/193,943 (2/28/14) ; #8623196 (1/7/14)
MICL02289 : Thermochemical Conversion of Plant Biomass to Liquid and Solid Fuels #14/061,460 (10/23/13); #PCT/US2014/031115 (3/18/14);
MICL02217:Evaluation, Development and Implementation of Sustainable Packaging Systems #14/069,556 (11/1/13)
;MICL02111: New Approach for Decontaminating and Improving the Quality of Fresh and Fresh-Cut Produce Utilizing Packaging Design and Chlorine Dioxide #14/233,314 (4/29/14); #14/069,556 (11/1/13);
MICL02007: Field-Operable Nano-Biosensors for Global Health, Biodefense, Food Safety, and Water Quality: #14/356,406 (5/3/14); #14/174,074 (2/6/14);
MICL02308: Improving biofuel crops by targeting biosynthesis and storage of mixed-linkage glucan in stem parenchyma tissue of model grasses. #14/365,744 (6/16/14); ; #14/349,137 (4/2/14); #61/842,077 (7/2/13); #PCT/US2014/044662 (6/27/14);
MICL01967:Engineering Methods to Improve the Safety of Commercially Produced Food Products #61/844,285 (7/9/13); MICL02240: Molecular Mechanisms Associated with Turkey Skeletal Muscle Growth and Meat Quality: #61/844,285 (7/9/13); MICL01981:Enhancing Economic and Nutritional Value of Food Products Through Food Processing Technology #61/844,324 (7/9/13); #14/054,388 (10/15/13)

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2014	Extension	Research	Total
Actual	0	25	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
2014	22

Output #2

Output Measure

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

Year	Actual
2014	194

Output #3

Output Measure

- Number of adults trained in home and commercial food safety.

Year	Actual
2014	7329

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.

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
2014	5

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 and/or apply technology to ensure that the Michigan fruit, vegetable, chestnut and canola oil industries remain economically and environmentally sustainable; develop and process dairy foods that are consistent with the benefits of ingesting probiotics; develop improved methods for the design and operation of thermal processing systems for protein foods; develop technologies to support management systems for quality grains and oil seeds; evaluate the efficacy of processes and ingredients that impact known safety hazards in muscle foods; and to pursue new process technology for raw material pretreatment, fermentation, distillation and aging related to artisan distilling.

Results
A major emphasis under this project in this reporting year was on the study of Computed Tomography (CT) imaging, hyperspectral imaging, and spectroscopy, for automated detection of undesirable fiber in processing carrots. The research involved the collection of hundreds of field samples followed by CT scanning and a laboratory processing method to extract and measure fiber content in individual samples for direct reference to electronic measurements. Results to date are demonstrating the ability to directly and also possibly indirectly (through evaluation of certain physiological zones of the carrot such as the phloem and xylem that experience related changes in fibrous carrots) detect undesirable fibrous tissue with CT, at least in cases of

significant fiber presence. Analysis is continuing on the
hyperspectral and spectral data, which was collected on the cut top end of the carrots. Similar research has been conducted under this project on CT for internal quality evaluation of chestnuts and other commodities with good success. The carrot fiber detection study has also included extensive structural/component analysis for cellulosic and lignin content in an effort to better understand and quantify the material which is the focus of detection. Publications and professional presentations in addition to industry interaction have been outcomes of this project. This specific project is directed at development of a technique and technology for detecting an undesirable characteristic (heavy fiber), which can present a choking hazard to humans, especially infants, in addition to being an undesirable texture characteristic in carrot-containing foods in general.

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
2014	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: Synthesize, characterize and evaluate nanostructured interfaces that enable molecular level investigations of systems of medical, scientific and technological interests; investigate using radio frequency identification (RFID) in tracking, traciig and security issues related to the movement of goods through the supply chain; and to combine the novelty of nanoscale transducing material and biosensing techniques to address the detection and diagnostic challenges in food and water safety.

Results
The focus of this umbrella project is on the development of novel field-operable biosensors for rapid detection of bacterial pathogens of concern to global health, biodefense, food safety, and water quality. The following specific targets are of interest to this umbrella project: Mycobacterium tuberculosis, pathogenic Escherichia coli, and Salmonella species. Expected deliverables include bio-nano-conjugates and biosensor devices that have the following features: field-portable, handheld, lightweight, highly sensitive, specific, reliable, simple to use, inexpensive, and provide results in less than an hour. Applications to global diseases is highly innovative and could potentially transform diagnostic practices at local clinics and home-health. The biosensor devices can also be transformative when applied to field screening for biodefense, food safety, and water monitoring. Because these devices are inexpensive, they could be critical tools in reducing healthcare costs.

Our technologies were featured during the National Summer Teacher Institute held on August 10-14, 2014 in Santa Clara, CA. The Institute was sponsored by the US Patent and Trademark Office. The Institute was attended by about 40 high school science teachers from about 20 states. The impact of our technologies is potentially far reaching as these teachers would be developing academic curricula about technology innovation which would then educate thousands of young people who will be our next-generation scientists and innovators.

Our technology on anti-counterfeiting devices is continually featured in the Science of Innovation educational program by the National Science Foundation and the US Patent Office through the NBC Learn as a national resource to encourage and recruit K-12 students to the science fields. The video is entitled "Science of Innovation: Anti-Counterfeiting Devices" and can be viewed at www.nbclearn.com/innovation/cuecard/62970. This material will impact thousands of K-12 students and teachers not only in the US but also around the world. My TEDMED talk continues to gain audiences from many sectors. The TED talk is featured in the following website: http://www.youtube.com/watch?v=QGauiO0Eev0

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
2014	5

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
During wheat milling, bran is separated from the endosperm, although a clean separation is not possible and there is always some starch adherent to the bran. Understanding the physicochemical properties of bran starch and its relationship with bran tissue is required to maximize bran utilization. In this study, bran starch had a higher percent of small starch granules, a higher amylose content, higher crystallinity, broader gelatinization temperature range, higher enthalpy of gelatinization, lower retrogradation rate, and lower pasting peak and setback viscosities than those of the counterpart endosperm starch. A-type X-ray diffraction patterns were found for both bran starch and endosperm starch. Bran starch content was found to be negatively correlated with percent large bran particles (greater than 2 mm). The neutral

saccharide profile of the wheat bran was dominated by arabinose, xylose, and glucose, whereas mannose and galactose were present in small amounts. Environment (i.e., crop year) affected the contents of arabinose and xylose in the bran of the studied varieties. Bran thickness was found to be positively correlated with bran starch content. Bound ferulic acid (BFA) and BFA to xylose ratio showed positive correlations with percent large bran particles and negative correlations with bran starch content. SEM images revealed that the outer layers of wheat bran were deformed after milling and the aleurone layer was no longer visible. Milled bran tissue was about twice as thick as intact outer layers of the wheat kernel. Observed relationships between bran characteristics and bran starch content explained why there was a correlation between percent large bran particles and bran starch quantity.

The importance of muscle as a food is exemplified by the turkey meat processing industry. In the USA, there has been a continual increase in consumption of turkey meat from 4.9 pounds of boneless equivalent in 1960 to 14.4 pounds in 2002. Breast meat yield is the primary profit center for the commercial poultry industry. A predominant factor leading to this increase in consumer consumption is that poultry breast meat is regarded as the ideal lean meat for a healthy diet. This is coupled to its affordability and ease of preparation. A 1% increase in breast yield will amount to at least $75 million increase in revenues
to the poultry industry. Commercial geneticists have placed a tremendous amount of selection pressure on breast yield and conformation, but not the mechanisms regulating the growth of muscle. The ability to regulate the growth and development of muscle depends on understanding the cellular regulatory mechanisms and cellular interactions that occur. Changes in muscle fiber size, extracellular areas available between the individual fibers and fiber bundles, and increased fat deposition will alter meat quality as have been illustrated by problems like pale, soft, and exudative turkey and pork. The results from this study will provide information on the role of specific genes whose function is currently poorly understood, on the growth and development of muscle. Results from these experiments will also enable breeders to develop strategies for genetic improvement of
animals which will yield higher quality meat at low cost.

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
2014	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
To expand the use of ClO2 as a sanitizing agent for fresh produce, a thorough analysis of the by-products that result upon the interaction between gaseous ClO2 and the organic matter as well as its implications in human health are needed ClO2 primary by-products include chlorite, chlorate, chloride. The current methodologies for assessing the byproducts were not accurate or precise, with the new methodology it is possible to accurately track the interaction of ClO2 gas with the fresh produce.The new system allow us to identify what is the more effective treatment for specific fresh produce. For example is the specific treatment for a specific fresh produce high concentration short time (treatment applied during the packaging process) or it is low concentration long exposure time (sustain release treatment and applied within the package system). Inorder to model and evaluate the packaging design and assess the distribution of the gas in the package it is critical to identify the mass transfer profile of ClO2 gas in air at different temperatures and in presence and absence of light. Most of the mass transfer data reported had been determined theoretically. Therefore our work in the mass transfer and determination of the diffusion coefficient is very important.

Our work on Tallman lettering, a technique where the dissimilar portions of look-alike, sound alike drug names is capitalized,
provides objective evidence supporting the Tallman strategy as helpful in differentiating drug dopplegangers. This is significant as the Institute for Safe Medication Practices (ISMP) estimates that about 25% of medication errors result from look-alike, sound-alike drug names which are easily confused (Joint Commission and the WHO, 2007). In fact, both members of the research community (Lambert, 1999) and official agencies (Joint Commission and the WHO, 2007) have concluded confusable drug names to be one of the most common causes of medication error, and an issue of significant global concern. This publication is currently under revision for possible inclusion in the Journal of Applied Ergonomics.

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
2014	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
The lab's solid fuel research centers on developing a water resistant briquette or pellet. Hydrophobicity, energy density and grindability of the torrefied material are key properties that

must meet benchmarks before adoption of this renewable option will become widespread. In addition to solid fuels, liquid fuel from biomass, using pyrolysis and electrocatalysis, is being investigated that could supply renewable feedstock to America's petroleum refineries. Electrocatalysis is used to saturate carbon-carbon and carbon-oxygen double bonds using electricity from wind and solar energy sources.

During the past year we have identified four genes from the model grass Brachpodium distachyon that show strong and exclusive expression in stem parenchyma cells. We have cloned the promoters from this genes and have generated binary vectors which can be used to express genes with these promoters in monocot plants. We have used these constructs to transform Brachypodium plants with a gene that synthesizes mixed-linkage glucan. We are currently growing these plants and will shortly begin to analyze them for the expression of the gene and for the presence of mixed-linkage glucan.

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
512	Quality Maintenance in Storing and Marketing Non-Food Products

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 2013-2014 fiscal year, ABR and MSUE was able to start rebuilding some of its resources after several years of either flat or funding cuts at both the state and federal levels. ABR was able to **fill voids in its research and support teams by hiring quality, skilled people for a variety of positions ranging from farm managers and grant coordinators to faculty and research technicians**. **Much needed equipment and infrastructure updates were also conducted at many on-campus and outlying research facilities**, helping to keep operations to full capacity. In 2014, ABR and Project GREEEN funds helped bridge operating budget gaps at five of the 13 outlying research centers, enabling the repairs of equipment and several buildings. Together, the organizations look to re-invigorate the MSUE presence at the 13 outlying research centers throughout the state.

The **ongoing economic challenges** faced by Michigan continue to affect this planned program area. Consequences have included fewer new hires, delaying the award of new financial obligations, reducing levels of continued funding, and renegotiating or reducing the current scope of assistance through formula funds or block grants. Specifically, a 15 percent decreases in state funding FY2011-2012 coupled with a flat federal funding line for the following two years resulted in the elimination of 72 Extension educator positions across 83 counties, 22 academic and faculty positions on campus and 15 support staff. Administrative positions were reduced from 45 to 19 FTEs. Impacts on ABR came largely in the form of reductions in research infrastructure support. Investments in facility maintenance and equipment were postponed in an effort to avoid eliminating more than 45 research positions (faculty, support staff and graduate assistants) and one research facility had to be closed in light of the reductions. There were also fewer funds to seed research on emerging issues.

Recent **extreme weather events** also caused extensive hardship to the agriculture industry. The spring 2012 ranks among the most destructive weather periods in Michigan fruit production history, with crop losses valued at more than $500 million. Peach production suffered a 95 percent loss; tart cherry, a 90 percent crop loss; apple production, an 88 percent loss; and grapes, an 85 percent loss. The summer 2012 brought the worst drought in Michigan since 1988 with many crops suffering substantial losses.
And the winter of 2013-14 brought a series of bitterly cold air masses rolled down from the Arctic, through Canada and into Michigan. The period between November 2013 and February 2014 was the coldest in Michigan since 1911 and among the five coldest periods on record in the state.

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

Research
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.

Extension
Example of evaluation results for home and commercial food safety include:

Situation & Need for Educational Programming:

Food Safety is a global issue from farm to table. Its impact on human health is significant across the life span with emphasis on certain vulnerable populations. Food-borne illness outbreaks occur on an ongoing basis crossing all socioeconomic lines from production,

consumption and preservation of foods. Overall health is impacted by the safety of the food supply and foodborne illness. According to public health and food safety experts, each year millions of illnesses in this country can be traced to food-borne bacteria. While the likelihood of serious complications is unknown, the Food and Drug Administration estimates that two to three percent of all food-borne illnesses lead to secondary long-term illnesses. For example, certain strains of E.coli can cause kidney failure in young children and infants; Salmonella can lead to reactive arthritis and serious infections; Listeria can cause meningitis and stillbirths; and Campylobacter may be the most common precipitating factor for Guillain-Barre syndrome. Food-borne illness costs the U.S. economy billions of dollars each year in lost productivity, hospitalization, long-term disability, and even death as these statistics reveal.

What has been done:

MSUE implemented a food safety program that delivered classes and presentations on Good Agricultural Practices (GAP) that prepare farmers to sell their produce in retail markets and ensure the safety of their produce for sale. In these programs, participants learned about topics in produce safety, responsibility in food safety, good agricultural practices and how to implement changes in their operation that can further enhance quality and safety of their food. Presentations were available online or through designated partner locations.

Results:

During 2014, Chipping potato farmers have implemented new practices on over 10,000 acres that further enhanced the safety of our food supply as a direct result of the services that MSU Extension provided.

• 442 Farmers (food producers) became more aware of food safety issues by participating in Good Agricultural Practices (GAP) audits and other food safety programs.

• At least $40,020,000 dollars of Michigan produce was improved in safety this year as a direct result of MSUE programming and consultation on good agricultural practices.*

*Three chipping potato growers producing a total of between 10,000 and 13,000 acres of chipping potatoes annually. Each acre produces an average of 345 cwt/acre and average gross revenue of $11.60/cwt

Key Items of Evaluation

Research

Millions of Americans with diabetes use a variety of meters to check their blood glucose levels and manage the disease. This concept is spurring Michigan State University (MSU) AgBioResearch scientist R. Mark Worden to commercialize a biosensor system that would have widespread applications in other venues, such as food processing facilities or clinical laboratories that assess high volume samples from many sources. Worden, a professor in the MSU Department of Chemical Engineering and Materials Science (CHEMS), began working in oxidation-reduction reactions, also known as redox, in the late 1990s. These chemical reactions are important in a number of areas, including biofuel production. As the research progressed, Worden developed expertise in nanotechnology and biocatalysts, which are often used to perform chemical transformations on organic compounds.

Over the years, various stages of this project received funding from the National Science Foundation (NSF) and other organizations. In looking at various aspects of these reactions and trying to exploit their economic benefits, Worden developed a biosensor system that was recently patented by MSU.

Extension

MSUE utilizes the Institute Work Teams for planning, evaluating and reporting. The Health and Nutrition Institute Food Safety Work Team found as a result of attending the food preservation workshop:
- 816/850 (96%) will follow research based/tested recipes for home food preservation
- 826/850 (97%) will use correct processing methods to safely preserve low and high acid foods
- 821/839 (98%) will use correct processing times to safely preserve low and high acid foods

Other evaluations found:

- 1131 participants gained knowledge in preserving foods including canning methods for low and high acid foods and methods for freezing and dehydrating foods
- 342 participants implemented 2 or more actions related to a safe food environment
- 621 participants correctly answered 75% at the end of session questions on knowledge/competency tests
- 746 gained knowledge on the proper process for hand washing
- 742 participants gained knowledge on cross-contamination
- 589 participants gained knowledge on safe temperatures for cold and hot foods/cooling hot foods and storing temperatures
- 6 producers become more aware of food safety issues by participating in GAP audits and other food safety programs.

VI. National Outcomes and Indicators

1. NIFA Selected Outcomes and Indicators

Childhood Obesity (Outcome 1, Indicator 1.c)	
27598	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)	
7084	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.