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

Status: Submitted

Date Submitted: 03/31/2017

I. Report Overview

1. Executive Summary

The Montana State University (MSU) College of Agriculture (COA) and Montana Agricultural Experiment Station (MAES) and the Montana State University Cooperative Extension Service (Extension) are pleased to present this joint 2016 Annual Report of Accomplishments and Results. The report not only highlights annual accomplishments, it represents the breadth and depth of MSU Extension, COA/MAES leadership and productivity in the many aspects of twenty-first century agriculture science, outreach, education and innovation in Montana. Leading the state in cutting-edge research and delivering timely information to stakeholders continues to serve the mission of the university. The ground-up structure with Extension agents living and working across the state helps ensure true engagement with producers, families, businesses and communities, as many projects are born from the people of the state. This year, the university was again proud to honor the responsibility of being the state's singular 1862 land-grant designated institution, while working closely with Montana's seven other 1994 land-grant colleges. The result is a state with the most land-grant institutions in the nation, and a growing, collaborative statewide-system of land-grant colleges.

COA/MAES and Extension 2016 accomplishments and results represent modern day achievements of 124 years together of honoring the legacy and commitment within the land-grant tradition in Montana. Smith-Lever funds continue to support Montana's 92 County and Reservation Extension Agents, and 32 specialists who translate applied research and deliver impactful programs to Montana's diverse demographics. Smith-Lever, Hatch-Act and State of Montana funding continue to allow MSU's faculty scientists to meet the changing needs of Montana, explore unique solutions to pressing questions, and solve global problems in agriculture. Combined, these funds operate as the critical foundation for COA/MAES and Extension to be successful in competition for complimentary national-level grant funding and provide meaningful teaching, research and outreach in a state where agriculture is a main cornerstone of the economy.

The college consistently ranks in the top tier of the university's annual research expenditures, which totaled $36 million invested in agriculture science research in 2016. Additionally, Extension, COA and MAES hired nine new faculty this year, each with tripartite extension, teaching and research appointments. MSU continues record enrollment growth, and is now the largest public land-grant university in the Western Region of the Northern Great Plains. The Extension and agriculture research arms of the university continue to innovate new programming and research that speaks directly to current and future challenges and opportunities across Montana's demographics and economic drivers. This report highlights both long-term, traditional programs, as well as innovative programs that are early in their development.

Montana 2016 Agricultural Statistics

- Montana land in farms and ranches totaled 59.7 million acres, or 65% in pasture and range and 29% in cropland of the state's land base. There are 27,500 farms and ranches in the state. Montana again ranks second in the U.S. in acres devoted to farms and ranches with annual crop and livestock cash receipts exceeding $4 billion.

• The 2015 market value of crop production decreased to $1.8 billion, a decrease of $403 million from 2013. The value of livestock decreased in 2016 to $2.2 billion, down $15.6 million from 2014. Total cash receipts (excluding government payments) for crops and livestock totaled $3,839,066; crops totaled $1,969,590 and livestock totaled $1,869,476.

• According to the "2016 Montana Agricultural Statistics," published by USDA, NASS and Montana Department of Agriculture offices, agriculture demonstrated an 8% decrease in cash receipts, down $391 million from 2014.

• Montana hosted 13 foreign trade delegations and 60 visitors from seven nations interested in purchasing Montana exports (particularly grains).

• Montana remains the number one producer of dry peas and lentils. Montana producers have increased the value of what they sold by 59% from 2007 to 2012, while producers nationally increased their production value by 39%. The 2014 crop year faced warm and limited precipitation, but when precipitation was received hail often accompanied the storm. Montana documented a record amount of acreage damaged by hail.

• Montana wheat production represents 10.3% of the U.S. total and cattle and calves represent 2.8% of the U.S. total.

Tribal College Partnerships in 2016

Montana is home to eight land-grant institutions, the most of any state in the nation. Of the eight, only Montana State University, which includes MAES through the Hatch Act and Extension through the Smith Lever Act, is part of the original Morrill Act of 1862. The other seven are tribal colleges that received land-grant designation through the Elementary and Secondary Education Reauthorization Act of 1994. These institutions and their tribal affiliations are; Anaiih Nakoda College (Gros Ventre and Assiniboine), Blackfeet Community College (Blackfeet), Chief Dull Knife College (Northern Cheyenne), Fort Peck Community College (Sioux and Assiniboine), Little Big Horn College (Crow), Salish Kootenai College (Bitterroot Salish and Pend d'Oreilles) and Stone Child College (Chippewa-Cree). Having eight land-grants is a growing source of pride for Montana as there are increasing numbers of partnerships that create comprehensive connections among them and elevate all citizens through the tripartite mission of research, education and outreach. The 1994 tribal colleges serve primarily American Indian populations located in remote, under-served communities that otherwise lack access to higher education. They are critically important to the people they serve and include culturally relevant curriculum and programs that enhance cultural and historical identity. In addition to adopting the land-grant mission in 1994, five of the reservations also partner with MSU Extension through the Federally Recognized Tribal Extension Program (FRTEP). The Blackfeet, Flathead, Fort Belknap, Fort Peck and Northern Cheyenne reservations all have Extension agents who live and work in the community and perform duties much like county agents.

Each of the seven 1994 institutions is found on a unique Montana reservation. These are; Blackfeet, Crow, Flathead, Fort Belknap, Fort Peck, Northern Cheyenne, and Rocky Boy. The seven reservations collectively span nine percent of Montana's land and include 12 federally-recognized sovereign tribal nations. These are: Assiniboine, Blackfeet, Chippewa, Cree, Crow, Gros Ventres, Kootenai, Little Shell, Northern Cheyenne, Pend D'Oreille, Salish, and Sioux. The reservation's sovereign and tribal governments establish services for their citizens. There are also many Indian people who live off-reservation in communities across Montana. The Montana constitution, created in 1972, includes in Article X, section 1(2): "The state recognizes the distinct and unique cultural heritage of the American Indians and is committed in its educational goals to the preservation of their cultural identity." In 1999, the Montana Legislature passed the "Indian Education for All" law as a way of being more intentional about

fulfilling this constitutional obligation (§ Mont. Code Annotated 20-1-501). Every public agency, and all educational personnel are called to work cooperatively with Montana tribes when providing instruction and implementing educational goals, and to include information specific to the cultural heritage and contemporary contributions of American Indians.

The COA, MAES and Extension cooperatively design and implement programs that best align with Montana's sovereign Indian Nations. Because this demographic is largely underserved and underrepresented, programs and goals were targeted to generate strong and beneficial interactions regarding respective Montana reservation struggles, priorities and needs. COA/MAES and Extension again worked closely with tribal councils and colleges across the Rocky Mountain region, and agents and educators provided a variety of academic programs and opportunities within tribal communities. Cooperative efforts provided resources and training in livestock management, childhood obesity, food preservation and safety, pasture restoration, environmental stewardship, sustainable agricultural practices, resource and risk management, pesticide certification and more. American Indians and other minorities regularly participated in MAES and Extension programming not on reservations or targeted toward tribal needs, as well. Cultural sensitivity and inclusiveness again remained an institutional priority for all COA, MAES and Extension programming.

At the university level (though outside COA/MAES and Extension Smith-Lever or Hatch-Act funds), MSU has taken significant pointed steps to allocating and garnering federal funding to reduce public health and economic disparity across tribal communities, while investing in programs that support the recruitment and retention of native students. In November, the university garnered a $1.3 million grant to recruit and educate American Indian school leaders. MSU also recently launched a Center for American Indian and Rural Health Equity Center, following a $10.7 million five-year grant to address rural health disparities in Montana from the National Institutes of Health.
Additionally, On July 11, 2016 as part of the 2016 Western Region Joint Summit Meeting of the Western Association of Agricultural Experiment Station Directors was hosted by MSU COA/MAES in Bozeman. The meeting included a special session highlighting extension-based components and efforts addressing the topic of "Fostering of Authentic Dialogue: Meeting Indigenous student needs in higher education" in addition to revisiting and editing the Western Agenda, a formal report and documents that demonstrate to decision makers and stakeholders the value of the Western U.S. and the contributions of Western Land-Grant Universities to the nation's agricultural economy. Additional efforts included the inclusion of Tribal Colleges in dialogue (much of which remains Extension-based) and facilitated conversations among 1994 and 1862 land-grant institutions and representatives at a September 22-23 meeting in Jackson Hole, Wyoming as part of the WAASED Engagement & Success of Land Grant Universities and Colleges agenda.
Montana is also home to about 50 Hutterite colonies (population 5,200) and a small number of African Americans (.5%), Asians (.5%), and Hispanic/Latino (4.8%) citizens. Recent growth and recession in some mining communities has increased the number of migratory and transient workers in some areas. Cultural sensitivity and inclusiveness remained an institutional priority for all COA, MAES and Extension programming.

Due to increasing competition in federal funding, in conjunction with several faculty assignments having left for new institutions, the COA/MAES saw a decrease of 6.2 percent in FTE representation. However, since the calendar year began in January 2017, COA/MAES has hired seven new faculty positions across five departments and seven remote research stations, with more faculty appointments (college-wide) expected to be filled in coming months.
COA/MAES and Extension have always maintained a close relationship, and though operations are officially separate, this 2016 Annual Report of accomplishments is completed as a joint venture. The opportunity to enhance this partnership and elevate agriculture in Montana is valued and represents a clear commitment to the heritage of the state.
In addition to agriculture, Extension also maintains a strong focus in elevating local communities, families

and youth through programming in: Community Development, Family and Consumer Sciences and Youth Development. The Local Government Center provides training and resources for elected county and municipal officials. Family and Consumer Sciences agents and specialists are actively working on mental health research and initiatives. Montana 4-H continues to be the largest youth organization in the state with thousands of youth learning valuable life skills such as public speaking and being good citizens, through science, technology, engineering and math (STEM) and other projects and activities. As the goal statements and outcomes throughout this report attest, the challenges and opportunities in Montana are endless. Increasingly, COA/MAES and Extension collaboration serves a growing, diverse constituency with limited, competitive resources.

In 2016, the Montana agricultural community worked together to reinforce the priorities for COA/MAES and Extension. Investigators and stakeholders facilitated focus groups and community meetings throughout the state, ensuring the research and outreach priorities were current and valid for the target population. Following is a list of priorities and planned program areas reported on in this document:

- Add value to Montana's high quality crop and livestock systems
- Develop effective livestock disease control methods
- Develop higher yielding and higher quality cultivars
- Expand research on agricultural and natural resource interactions
- Explore alternative and new crops
- Improve beef production practices and evaluate genetics to improve herds
- Increase research programs on alternative energy sources, including crops for biofuel
- Disseminative timely and impactful information on federal agriculture programs and legislation, so that Montana's agricultural community is equipped with the latest knowledge for on-farm and ranch decision making.
- Conduct research and outreach that improves the health of Montana's forests and water
- Increase the leadership skills of youth, volunteers and adults
- Provide training and education to increase quality of life of Montana families
- Increase access to healthy, nutritious foods through food preservation, food safety, financial and general education to youth and families
- Increase the sustainability of local communities by developing and/or supporting community foundations
- Provide emergency/disaster planning and management tools, resources and education

ANNUAL REPORT PROGRAM AREAS:

1. ANIMAL SCIENCES

Animal health research is of primary importance not only to Montana's beef producers, but for the larger global safety of Montana's food and product exports. Animal Sciences encompasses research priorities in animal health in direct correlation with humans, livestock, or food products. Primary research veins reflective of these areas are; vaccinations, nutrient utilization, reproductive performance, animal physiology, zoonotic diseases, external parasites, animal diseases, genetic improvement of animals and management of range resources. Producing the highest quality animals and obtaining the highest profit potential are essential for Montana. 2016 accomplishments in promoting and maintaining animal health has led to advances in genetics, reproductive science and improved animal performance. Scientists continued to investigate vaccines for rotavirus, strangles, respiratory diseases, and mastitis. Researchers used feed studies with barley, camelina meal, and supplements to evaluate varying rations for calves and cows, for continued production of superior feeder stock to markets outside of Montana. MSU Research and Extension partnered with producers to address issues and needs of Montana's agricultural industry in a variety of animal health topics, largely the reproductive performance in animals, nutrition, genetic improvements for herds, and developing better animal management systems. The majority of the Animal

Health program focused on pre-harvest research and investigation; namely neo-natal health of livestock, disease resistance and best breeding practices. Food safety and security continued as important concerns for the beef industry at all production levels. COA/MAES and Extension helped to ensure that Montana producers raise safe beef while improving the quality of the beef and ensured consumers are aware of the quality and health of their products through advancements in educational programs on beef quality assurance (BQA) practices, voluntary beef cattle marketing options, and ranch management issues throughout the state via meetings, one-on-one discussions and interactive technologies. Food safety within Animal Health also involved mycotoxins in grains and feeds. Finally, the University and several statewide producers garnered together competitive funding for the MSU College of Agriculture's first Endowed Chair in Animal Science and Beef Physiology. The chair is charged with leading a research profile of a lab, graduate and undergraduate students and an advisory council, that will conduct meaningful and timely research that mirrors, enhances and sustains Montana's beef industry.

2. PLANT AND SOIL SCIENCES

2016 research accomplishments in Plant Sciences spoke to the plant science, genomics and pathology that have a direct impact on increasing yield potential, improving winter hardiness, enhancing disease resistance, and improving dual-purpose end-use quality grains. MSU's intensive genomic research helped Montana producers stay competitive and provided improved cultivars adapted to Montana's climatic conditions and cropping systems. Continued productivity of breeding programs improved the understanding of the genetics from key traits and produced the development of new selection tools. This year, the Montana Legislature funded $2.3 million in economic development funds to replace crop fallow systems with pulse crops and cover crops for hay and forage. The university, in 2015, formally welcomed its first Montana Plant Science Endowed Chair, MSU's first endowed chair dedicated to leading, sustaining and enhancing Montana's crop industries from a robust university research profile. The broader impacts of the work were a larger and higher quality food supply for the world, an improved ability of Montana farmers to compete in a global marketplace, and a strengthening of export markets for U.S. wheat. MSU faculty and researchers continued to garner national notoriety in their horticulture research in biology, chemistry, plant materials and physiology, plant pathology, plant reproduction and arboriculture. COA, MAES and Extension faculty conducted and led programs in cereal quality, genetics, cropping systems, molecular and conventional approaches to plant improvement, plant breeding, molecular genetics, biochemistry and agronomy. Much of the current research conducted in campus labs and in fields across the state was centered on disease resistance through genetics, bacterial diseases and the biochemistry and molecular genetics of plant diseases. Many research projects were and remain problem-oriented and pertain to major plant pathological problems in the state. MSU Extension's horticulture programs, publications and links provided expert yard, garden and urban integrated pest management resources for individuals and businesses throughout Montana. Most notably, this year, MAES developed the wheat varieties that Montana farmers planted more than any other variety for the 2016 crop year, according to the United States Department of Agriculture National Agricultural Statistics Service Montana Field Office. The statistics show that 5.28 million acres of wheat were planted in Montana last year, making it the third-highest state for planted wheat acres in the country. MAES-developed spring and winter wheat varieties accounted for 2.3 million of those acres, or approximately $500 million of $1 billion of wheat sold by Montana farmers in 2016, according to MSU wheat breeding specialists. Some wheat varieties developed and licensed by MSU are sold by private companies. Montana exports 20 percent of agricultural products as foreign exports and 75 percent of its wheat to Asian markets, according to the USDA.

Montana producers planted 2.3 million acres of winter wheat for harvest in 2016. MAES-developed varieties Yellowstone, Judee and Warhorse were the top three winter wheats planted last year, with high-yielding Yellowstone accounting for 18.8 percent of the state's planted acreage. Judee and Warhouse accounted for 18.1 and 10 percent of all winter wheat planted, respectively. Montana is ranked fourth for winter wheat planted acres in the U.S., according to the USDA National Agricultural Statistics Service, Montana Field Office.

Montana producers also planted 2.3 million acres of spring wheat for harvest in 2016, of which 18.8 percent was the MAES-developed Vida, a hard, red spring wheat. This is the sixth year in a row that Vida

has been the state's leading spring wheat variety planted. Montana is the second-largest spring wheat producer in the country, according to the USDA National Agricultural Statistics Service, Montana Field Office.

3. FARM, RANCH AND BUSINESS MANAGEMENT
COA/MAES and Extension faculty again supported Montanans in managing their farms, ranches and similar enterprises as businesses in 2016. Collectively, the faculty capacity ensured best practices, contracts and estate planning, marketing from an ag perspective, taxation, accounting, operational planning, budgeting, agricultural policy and commodity support programs, risk management and decision support software for Montana. MSU Extension faculty and specialists ensured Montana producers understood implications and changes within the 2014 Farm Bill and MSU agricultural economics faculty continued evaluating, engaging and researching federal agricultural policy that directly affects regional producers.

4. INTEGRATED PEST MANAGEMENT
An increase in public concern about food safety, quality, cost, biodiversity, and the sustainability of natural resources such as soil, air, and water quality is pushing scientists to rely less on pesticides and look for more environmentally-friendly options. In 2016, researchers again explored new and improved methods to identify and control insects, weeds, and diseases challenging Montana farmers and studied biological controls as low impact pest control options to promote sustainable practices. Producers and researchers continued to evaluate these new integrated pest management (IPM) methodologies so that Montana growers can maintain a competitive position in U.S. and world markets. In Montana and throughout the U.S., maintaining profitable agricultural enterprises while sustaining ecological systems has become a difficult balancing act that often results in changes in agricultural practices and environmental policies. COA/MAES and Extension professionals continued quality in-depth training programs for continued integrated pest management education to discover, evaluate or change new IPM priorities and projects. Additional outcomes included new products registered, an increased passing rate percentage for pesticide application licenses and a number of new broad-ranging stewardship practices were implemented. The importance of integrated pest management remained a consistently critical field as invasive plant and pest species continue to threaten Montana's agricultural economy as well as the global safety of the state's food exports.

5. ENERGY & NATURAL RESOURCES.
Across Montana in 2016, energy and natural resource studies again became increasingly necessitated as major environmental changes accelerated. According to the Montana Department of Commerce, Montana has more potential for energy development from existing and untapped diversified sources than any other state in the nation. From coal deposits, oil, wind farms and geothermal energy potential, energy and natural resources have played a vital role in Montana's history and continue to be a priority for Extension and MAES. COA/MAES and Extension faculty continued to recruit competitive grant dollars and personnel to bolster current and forecasted research faculty lines, undergraduate and graduate students, programs and labs, as they relate indirectly and directly to the field of energy and natural resources. This program saw an increase of nine new Hatch projects, many of them interdisciplinary in nature - as they speak to research areas that rapid environmental change and natural resource and energy development has affected. The agricultural community in Montana wants to add value to Montana's high quality crop and livestock systems in ongoing adaptations in regard to the state's energy and natural resource base. Faculty in 2016 prioritized research exploring water, and researchers also explored climate in the wake of threatened natural resources. COA/MAES and Extension professionals continued to make advancements in this critical research agenda and continued excelling in the discovery and communication of how natural and managed environments and their elements function in an era of global climate change. With more than 60,000 miles of perennial streams providing irrigation, drinking water and recreation, Extension and MAES partnered with communities and citizens to involve local people with data collection to better understand surface and groundwater issues. In addition, forests cover large areas and contribute

to the economic base of the state while also serving as a critical natural resource for wildlife, recreation, tourism and cultural purposes. Extension and MAES provide unbiased, science-based research, education and outreach related to preserving and supporting the best use and management of these resources.

6. YOUTH AND FAMILY DEVELOPMENT
MSU Extension continues to provide extensive resources and support to Montana's youth and families. Focused on citizenship, healthy living and science, Montana 4-H is a trusted source of education, skill building and activities for youth and volunteers. In addition, Extension supports youth through afterschool programming and nutrition, financial and other educational opportunities. Family support is provided through e-Parenting, the Grandparent's Raising Grandchildren Program, Powerful Tools for Caregiving and other opportunities that vary from town to town in order to meet specific needs. Extension's citizenship and international programs coordinator and her team of volunteers earned the 2016 States' 4-H International Outstanding Quality Program award and Diversity in Hosting award for the professionalism and consistency in on-time placement of delegates. Together, families and Extension provide thousands of hours of service in their communities. During the 2016 Week of Service alone, more than 40 projects were completed including community clean-up, gardening, horticulture, food or supply drives, painting, maintenance and more. During that one week nearly 2,700 hours were contributed by 800 volunteers. MSU Extension's financial education programs also continued to be instrumental in assisting families with topics ranging from estate planning, to understanding loan financing and/or health savings programs to utilizing web apps for financial planning. Housing programs continued to provide training for Extension educators, public health professionals, and tribal housing/health entities to address issues such as mold and moisture, radon gas detection, hazardous waste disposal, home asthma triggers and more.

7. HEALTHY LIVING, NUTRITION & FOOD SAFETY
Food insecurity and hunger in Montana is real. The USDA Map and Meal Gap reports that 20.9 percent of Montana's children struggle with hunger, meaning they regularly have concern over whether they will have enough to eat. Access to enough food, and to healthy food specifically, is complicated by the great distances between grocery stores and sometimes poor availability of fresh fruits and vegetables. MSU Extension continues to provide nutrition education through the Supplemental Nutrition Assistance Program (SNAP-ed), and the Expanded Food and Nutrition Education Program (EFNEP). Part of these programs, as well as others, is teaching how to budget, how to utilize less expensive cuts of meat and how to safely store and preserve food, etc. MSU Extension also provides ServSafe food handling education statewide. Another focus of MSU Extension continues to be healthy living. As the cost of healthcare climbs, staying healthy has to be a priority and nearly every county and reservation offers education and programming to help families improve their diet and exercise habits.

8. COMMUNITY DEVELOPMENT
MSU Extension is continuing to work in communities across the state to educate elected officials, provide training to board members, offer support to Rural Community Foundations and act as organizers for a wide range of community needs. From building a new community kitchen to assist entrepreneurs with adding value to agricultural products, to fundraising to bring 3-phase power to an airport thus creating new jobs, MSU Extension faculty who live in the communities they work in are often central to bringing community groups together to meet objectives. On several reservations, the Extension faculty have worked alongside elders, youth and others to create gardens, trading posts and transportation plans to bring native fruits and vegetables to place-bound neighbors. Extension is also involved in research to understand how oil and gas boom and bust cycles impact communities; specifically, how to determine the local share of the economic benefits and how to assess actual local costs. Finally, Extension is working with the MSU Center for Mental Health Research and Recovery, One Montana, Stone Child College and Little Big Horn College to increase training in Mental Health First Aid and become facilitators of the Youth Aware of Mental Health program.
While the program overview and highlights in this annual report reflect just a portion of the many accomplishments during 2016, it does adequately represent the dedicated and committed talent that

collectively ensures Montana's success and longevity. Researchers at Montana State University COA/MAES and MSU Extension professionals also continued learning as they focused on diversity and efficiency in agricultural operations and continued to optimize grower profitability. Because of a statewide network of private producers, stakeholder groups, supported by COA/MAES and Extension faculty and staff, it is possible for MSU COA/MAES and Extension to remain committed to serving and enhancing citizen knowledge and production.
MSU Extension and COA/MAES continue to provide relevant, timely deliverables to the multitude of time honored as well as the fledgling Montana production entities. Farming and livestock production remain essential and solid pillars of the Montana economy that warrant continued educational (formal and informal) as well as research and outreach efforts. Together, MSU's three tenant programs of the land-grant mission does an admirable job in servicing the needs of a widely varied clientele. This report testifies to the vast and ever-evolving range of Extension and COA/MAES knowledge, expertise and services provided to an ever increasing diverse audience. On behalf of the Montana State University, we are pleased to present the 2016 Annual Report.

Total Actual Amount of professional FTEs/SYs for this State

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	174.0	{No Data Entered}	268.0	{No Data Entered}
Actual	125.0	0.0	307.4	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
- Combined External and Internal University Panel
- Combined External and Internal University External Non-University Panel
- Expert Peer Review
- Other (Dept. Head External to PI's Dept.)

2. Brief Explanation

Department heads with the MAES and COA review Hatch Projects at the departmental level. A committee of peers then reviews the project and passes it to the director for final approval. The MAES director's office ensures this process is done as efficiently as possible. The peer review committee, selected by the director after consultation with COA department heads, includes the principle investigator's (PI) department head, MAES administrator, one department peer reviewer and two additional faculty external to the PI's department. Researchers present seminars to the review committee and interested stakeholders, including faculty, staff, students, and constituents. The director requires researchers to propose new projects for a three year period, while researchers with favorably reviewed ongoing projects continue for five years. External expert reviews occur with Montana State University faculty outside the COA, as a requirement of the review process. Presenters announce all seminars ensuring broader

attendance and input potential. Reviewers provide written recommendations on the following: relevance and importance of the project; relationship of the project to previous research; objectives; approach and methods; scientific and technical quality; resources; environmental, economic, and/or social impacts. The MAES administrator and department head share the responses with the PI. If the projects do not meet expectations, the director will not approve them and will defer them until the researcher meets the key elements satisfactorily. Ultimately, the office staff submits the director-approved projects to USDA-NIFA for final approval.

MSU Extension uses a Merit Review Process for the Annual Report. Individual program leaders, agents and specialists submit program data, outcomes and impacts. Internal editors carefully read each section for content, grammar and overall quality review. In addition, an external Merit Review Panel consisting of passionate supporters with tremendous historical knowledge of MSU Extension and Montana carefully reviews the documents, providing important, expanded perspectives and input. This year the Merit Reviewers were: Dr. James Hafer (chair and instructor of the Agricultural and Natural Resource Science program at Chief Dull Knife College) and Charles Rust (retired agricultural economist and interim Director of MSU Extension.). This group was selected due to their experience related to Extension, outreach education and Montana culture.

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 specifically with non-traditional groups
- Survey specifically with non-traditional individuals
- Survey of selected individuals from the general public
- Other (Educational outreach programs)

Brief explanation.

Personal contact is one of the most successful ways for Extension to gain stakeholder participation. Clientele regularly provide input about which issues are important to them, their families and communities. In addition, Extension professionals reach out to others by staying in regular contact with commodity associations, various government agencies and other partners to assure they are aware of and understand the most current needs and concerns of clients.

Extension agents are located within Montana communities and are an active part of the day-to-day functions of towns, cities, counties and reservations. Agents are often members of community foundations and boards (such as county or tribal weed boards, chamber boards, school boards) and use the knowledge and information they gain in this capacity, as well as face-to-face meetings, to prioritize and strategize the best use of their time, dollars and other resources.

Many specialists spend an abundant portion of their time in fields, gardens, feedlots and town halls with the people they serve. They know that they must have a close relationship with key stakeholders to receive honest feedback and be considered as a valuable resource.

Radio, newsletters, newspapers, social media and electronic distribution lists are also used to inform clientele about the opportunity to make requests for Extension assistance. Informational booths are set up at agricultural trade shows, home and garden shows and health fairs, allowing for discussions with people who are not regular clientele of Extension. This kind of conversation reveals concerns and issues that might not be heard in the usual process. When common issues surface through these methods and the advisory process, they will be incorporated into Extension planning.

MAES and COA obtain stakeholder input on research priorities and programs through a small, yet well-connected group that represents the myriad interests in Montana agriculture. Stakeholder committees include the sustainable agriculture focus group, MAES State Advisory Council, Ag Coalition and other state and local groups. Agriculture interest groups consist of representation from the Agricultural Business Association, Farm Bureau Federation, Montana Stockgrowers, Montana Farmers Union, Montana Water Users, Montana Wool Growers, Seed Growers, and the Seed Trade. It meets periodically with the dean and director to review program priorities, new initiatives, fundraising efforts and legislative activities.

The College advertises the meetings via news releases, newsletters, individual letters and announcements at group meetings. The MAES responds to stakeholder inputs by considering their proposals at research planning meetings with scientists, advisory groups, and administrators. Administrators solicit stakeholder input at the strategic planning process and as programs are developed, implemented, and sometimes redesigned. Local advisory committees to the research centers also provide annual and long-term guidance to the College and MAES. MAES scientists routinely participate with these groups and National Resources Conservation Service to provide training and expertise in many program areas.

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.

The seven agricultural research centers have local advisory groups that meet multiple times through the year. In addition, a State Advisory Council meets three times each year to discuss program focus and direction, Montana legislative priorities, and productivity/impact. These meetings are open to the public. Administrators and faculty in COA/MAES serve on agricultural association committees that annually direct and fund research activities. These committees use a variety of collection methods, but the most common are face-to-face meetings, telephone, and some video conferencing.

The Montana Extension Advisory Council (MEAC) is a statewide group that meets annually to

discuss the overall direction and priorities for MSU Extension. Membership on MEAC is based on geographic representation, areas of interest, a tribal representative and an elected 4-H ambassador, and previous relationship with Extension. Recruitment from specific sectors such as healthcare, government agencies and community development are also targeted. County agents and state specialists, Extension program leaders and regional department heads are asked to make recommendations for membership to MEAC. Those who are elected serve a three year term.

Many counties also have local advisory groups. Membership on these boards is achieved by sending an invitation to traditional stakeholder groups requesting the name of an individual who can represent views and provide input for Extension programming. A similar invitation is sent to nontraditional groups. In cases where a group may not be familiar with Extension, personal contact is made to explain the role of the representative.

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 specifically with non-traditional groups
- Survey specifically with non-traditional groups
- Meeting specifically with non-traditional individuals
- Survey specifically with non-traditional individuals
- Meeting with invited selected individuals from the general public
- Survey of selected individuals from the general public

Brief explanation.

The most common method of gathering stakeholder input is from interaction with regular clientele of MSU Extension. Often this occurs in intentional program planning sessions to which these people are invited, requested to attend or are required to be present by their role or position. Examples of groups that may fall into this category are county/reservation 4-H Councils, livestock associations, weed boards, human resource coalitions, local and state agricultural organizations, Ag Research Center Advisory Committees and special interest groups. Some of these groups have officers or directing boards that are asked for specific input.

County and state advisory committees are also used to gather input. Advisory groups are generally comprised of a cross section of leadership and citizens in the county. Efforts are made to involve the underserved and underrepresented clientele by contacting agencies and organizations that regularly work with a particular audience. They are asked for input and/or for names of people who could provide input directly. Local Extension agents follow up with personal conversations to explain the goals and process.

At the state level, one of the most valuable sources of input is from the Montana Association of Counties (MACo). Extension makes presentations during MACo's Annual Meeting, followed by an open session for mutual dialogue. These types of discussions also happen during the newly elected

county commissioners' orientation and have proven very beneficial. Extension administration, through regional department heads (RDHs), also gathers stakeholder information from county commissioners.

Through direct participation with agricultural stakeholder groups, broad participation in committees, and directed meetings, MAES listens to and considers defined problems or questions that research programs can address. COA/MAES considers the voice of public stakeholders at every turn and works closely alongside various producer groups to critique and share applied research and methodology. It is common for many of Montana's public and private agricultural groups to hold meetings in COA/MAES facilities on campus, or for state-wide producers to volunteer a portion of their acreage for research studies. The director targets selective meetings with nontraditional groups. Montana has an open meeting law. Therefore, all meetings are open to the public and the organizer must publish an agenda.

During programs targeted at certain audiences such as Expanded Food and Nutrition Education Programs (EFNEP) and Supplemental Nutrition Assistance Program-Education (SNAP-Ed), attendees are asked directly for input or may be asked to serve on a specific advisory committee for the program area.

Occasionally, broad surveys or requests for information are made.

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
- Other (Create a basis for additional resources)

Brief explanation.

As a Land Grant Institution, Montana State University has a solid foundation of past and future program activities that allow stakeholder input and strong interactive dialogue, and the COA, MAES and Extension clearly set the tone for this interactive environment. The College, research centers and Extension serve as the primary conduit for connection and delivery of education and new knowledge in activities throughout rural Montana.

An example of how MSU COA/MAES and Extension have used stakeholder input is the work being done in Mental Health Research. Montana has led the nation in suicide for many of the last 30 years and has always been ranked in the top five nationally. Every county has mental health provider shortages. As part of the USDA-NIFA and Montana Mental Health Trust Fund grant, Extension was able to have four county faculty certified to teach the adult version of Mental Health First Aid. This 8-hour program is based off of the format of regular first aid. In this case, participants learn mental health literacy, what to do in the event of a mental health crisis, and how to link people in need of mental health services to such professionals. This is in response to many communities recognizing mental health as a critical need through community health needs assessments. Extension is in a position to begin conversations around mental health and to start community capacity building on the issue in communities all across the state.

Brief Explanation of what you learned from your Stakeholders

Stakeholders play a key role in our programs, and they are pleased with the direction the COA/MAES and Extension are going. During recent legislative hearings key stakeholders repeatedly testified about COA/MAES and Extension accomplishments from integrated pest management and wheat breeding programs, to youth development STEM, service and leadership activities and horticulture and gardening education.
It addition, Extension and MAES/COA address concerns of Montana stakeholders in a wide range of issues similar to those receiving attention across the nation. Many Montanans worry about job security and accessing healthcare in their rural community. Rural families wonder if local schools will remain open, or conversely if overcrowding or transiency will cause issues. In those areas where education can help address the issue, Montanans look to MSU Extension and MAES as an unbiased resource that can help them make choices and decisions that are best for their families, businesses and communities.

IV. Expenditure Summary

1. Total Actual Formula dollars Allocated (prepopulated from C-REEMS)			
Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
2742508	0	2764397	0

2. Totaled Actual dollars from Planned Programs Inputs				
	Extension		Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	1104500	0	2888640	0
Actual Matching	0	0	15246634	0
Actual All Other	1111744	0	12177984	0
Total Actual Expended	2216244	0	30313258	0

3. Amount of Above Actual Formula Dollars Expended which comes from Carryover funds from previous				
Carryover	0	0	2091771	0

V. Planned Program Table of Content

V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

Animal 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
121	Management of Range Resources	10%		7%	
301	Reproductive Performance of Animals	5%		10%	
302	Nutrient Utilization in Animals	5%		8%	
303	Genetic Improvement of Animals	0%		10%	
305	Animal Physiological Processes	0%		7%	
306	Environmental Stress in Animals	5%		4%	
307	Animal Management Systems	5%		5%	
308	Improved Animal Products (Before Harvest)	5%		5%	
311	Animal Diseases	10%		7%	
312	External Parasites and Pests of Animals	0%		5%	
315	Animal Welfare/Well-Being and Protection	10%		5%	
603	Market Economics	5%		5%	
604	Marketing and Distribution Practices	5%		3%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources	0%		3%	
722	Zoonotic Diseases and Parasites Affecting Humans	0%		8%	
902	Administration of Projects and Programs	0%		3%	
903	Communication, Education, and Information Delivery	35%		5%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	3.0	0.0	71.6	0.0

Actual Paid	5.4	0.0	79.0	0.0
Actual Volunteer	0.8	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**
106300	0	751553	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	4052767	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
73051	0	3856664	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

• Met one-on-one with producers, landowners and consumers to identify and address individual problems and solutions
• Encouraged email and phone conversations with members of the public
• Offered classes, workshops, group discussions, demonstrations, field tours/trials, webinars
• Shared information at farmer's markets, county fairs and other community events
• Attended and presented information at professional conferences, county meetings and state conventions
• Prepared and distributed public service announcements, newsletters, MONTGuides, Television (Montana PBS Montana Ag Live), eXtension, listservs, blogs, radio and other media
• Created readily available and easily accessible databases for producers and researchers
• Prepared research articles, fact sheets and news releases for scientists and statewide media
• Hosted strategic planning meetings with state agricultural groups
• Developed systems that ensure food safety and agricultural security
• Integrated best practices for beef quality assurance in programs
• Conducted exploratory research on infectious diseases and their management in Montana.
• Enhanced the competitiveness and value of U.S. beef in neonatal illness research
• Enhanced management, production and sustainability of grazing ruminants in extensive landscapes
• Developed and manipulated germ cell and embryo development and manipulation for the improvement of livestock
• Integrated approaches to enhance efficiency of feed utilization in beef production systems
• Researched nutritional management of range beef cows and calves
• Investigated the impacts of stress factors on performance, health and well-being of farm animals
• Developed nutritional strategies for steer and bull development
• Incorporated sheep into farming systems under animal health and performance, agronomic, economic, social and ecological considerations
• Investigated the growth path to carcass composition and meat quality
• Explored the role of microbiota in animal nutrition, health, and reproductive performance
• Researched Staphylococcus aureus colonization and infection in horses and cattle
• Researched Staphylococcus aureus colonization in humans and livestock

- Researched the pathogenesis of horse pathogen streptococcus equi

2. Brief description of the target audience

- Livestock producers
- Commodity Associations
- Land managers/owners (small and large)
- Weed Control Professionals
- State Agencies
- County Weed Boards
- Colleagues and related stakeholders
- Animal health businesses
- Legislators, county commissioners and other elected officials
- Rodeo team and related partners
- Tribal land managers
- Rural large-animal veterinarians

3. How was eXtension used?

Agents and specialists utilized eXtension to provide webinars and programming, share fact sheets, evaluate courses and programs (Moodle), conduct radio interviews, create Extension documents and as a general resource.

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	18601	87953	3067	1970

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

Patent Applications Submitted

Year:	2016
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	40	200	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2016	100

Output #2

Output Measure

- Number of publications on infectious disease and vaccines research

Year	Actual
2016	47

Output #3

Output Measure

- Number of presentations on infectious disease research

Year	Actual
2016	100

Output #4

Output Measure

- Number of undergraduate and graduate students trained in animal science and biotechnology

Year	Actual
2016	1000

Output #5

Output Measure

- Number of producers attending meetings/workshops and clinics

Year	Actual
2016	9332

Output #6

Output Measure

- Number of producers utilizing ration-balancing

Year	Actual
2016	3000

Output #7

Output Measure

- Number of Native American Youth completing quality assurance training and receiving Junior Ag Loans

Year	Actual
2016	21

Output #8

Output Measure

- Number of outreach, training and education events

Year	Actual
2016	2500

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Extension and MAES Beef Cattle Programs -Increase the number of producers using Extension and MAES information to successfully manage animal health and well-being issues. -Increase the number of producers who successfully utilize Extension and MAES programs to improve profitability. -Increase the number of producers who successfully utilize Extension and MAES to improve environmentally sustainable practices.
2	Extension and MAES Sheep Programs -Improve profitability of producers in the sheep and wool market through increased participation in and knowledge gained from seminars, classes and other educational opportunities; and expanding wool pools, wool delivery and marketing.
3	Identification of critical infection and disease resistance
4	Number of improvements in vaccines developed
5	Identification of genetic correlations and other factors influencing residual feed intake and feed efficiency; and education of producers and industry leaders with the latest scientific information
6	Conduct basic and applied infectious disease research -Increase the quality of meat, milk and fiber products -Reduce non-predator deaths in calves
7	Add value to Montana beef cattle through nutrition and management methods

Outcome #1

1. Outcome Measures

Extension and MAES Beef Cattle Programs -Increase the number of producers using Extension and MAES information to successfully manage animal health and well-being issues. -Increase the number of producers who successfully utilize Extension and MAES programs to improve profitability. -Increase the number of producers who successfully utilize Extension and MAES to improve environmentally sustainable practices.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	9108

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Beef cattle production results in the greatest share of agriculture receipts in Montana. The 2015 State Agriculture Overview report by the USDA indicates that Montana's cattle and calves industry brought in nearly $1.8 billion and cow milk another $44.6 million. The cost of supplementing feed and nutritional supplements for a beef cow herd are between 50-70% of the cash costs of producing calves in Montana. Challenges for Montana producers include high nitrate levels which can cause decreased weight gain, decreased milk yield, abortion and death; lack of understanding of the science behind grazing rotations; and absorbing impact of the new Veterinary Feed Directive.

What has been done
Classes, seminars, AgAlerts, MontGuides, Montana Ag Live television and various newsletters, websites and social media are used to educate Montana producers in making cost-effective feeding decisions based on cow nutritional needs, timing and alteration of grazing rotations, and more. Because each ranch has a unique set of available feed and forage, producer knowledge, and experience, Extension often utilizes one-on-one, in the field/pasture/barn interactions with producers. Offices offer feed testing and ration balancing assistance. Extension specialists created four new MontGuides (fact sheets) in 2016. Several counties are piloting advanced nitrate testing, while most offer the Nitrate Quick Test. For three years, specialists have prepared producers to be ready for the new Veterinary Feed Directive.

Results

Evaluations for beef cattle programming quality exceeded 4.5/5 scale and indicated that as many as 87% of participants would specifically utilize newly acquired knowledge in their operation. Following Veterinary Feed Directive education, the number of producers who understood increased from 53% to 86%. Understanding the rule may prevent negative impact on animal health as there won't be delay in accessing proper treatment for sick animals. Examples of one-on-one intervention impacts include:
-Used a cheaper whole corn supplement vs a process range cake to cut daily ration cost by 20%, the cows were well conditioned, had adequate milk and strong calves.
-A rancher who feeds 1500 replacement heifers reported saving 3% through ration balancing, alternate feedstuff analysis, nitrate testing and general information amounting to about $7,500.
- Six producers were prevented from feeding dangerously high nitrate feed which could have resulted in abortions or death of cattle.
- A producer who learned his water source was unhealthy had a new well drilled for his cattle.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
302	Nutrient Utilization in Animals
305	Animal Physiological Processes
306	Environmental Stress in Animals
307	Animal Management Systems
308	Improved Animal Products (Before Harvest)
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection
603	Market Economics
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
902	Administration of Projects and Programs
903	Communication, Education, and Information Delivery

Outcome #2

1. Outcome Measures

Extension and MAES Sheep Programs -Improve profitability of producers in the sheep and wool market through increased participation in and knowledge gained from seminars, classes and other educational opportunities; and expanding wool pools, wool delivery and marketing.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	971

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Montana State University has been directly tied with the sheep industry since its founding in 1893. Extension, COA and MAES have been deeply involved in generations' long breeding programs, expansive grazing and weed control initiatives and concentrated, strategic efforts to make Montana wool more competitive in the world market. Impactful engagement at all levels has enhanced the industry which supports 230,000 plus sheep, earning Montana a ranking of 10th in value of sales nationwide at over $31.2 million annually. Current research seeks to identify genetic and genomic tools that eliminate the need to measure large numbers of animals for various traits, instead allowing for a streamlined approach to predicting performance; and providing decision making tools for internal parasite issues.

What has been done
A long-term breeding program involving Rambouillet sheep selected from genetically distinct populations was created. The program seeks distinct genetic markers, gene expression patterns and altered physiology that provide candidate gene markers for the reproductive efficiency in other sheep and livestock species. Extension hosted 26 seminars (971 producers) including: managing ewe nutrition through body condition scoring and quantitative selection strategies; wool selection, management and quality considerations for optimal profit; and wild and domestic sheep interests: working together. To combat a shortage in the industry, Extension hosts an annual, hands-on sheep shearing school. Extension also helps manage regional wool pools which increase profit of producers.

Results
Because of the Sheep Shearing School, at least 20 individuals are working for hire with every Montana-based commercial shearing contractor using at least one of the graduates. The manager at Center of the Nation Wool warehouse was quoted as saying that the improvement in genetics and harvesting practices has made the wool from this region the most sought after wool in the world by the textile industry.
In one wool pool, 37 producers delivered 36,676 pounds of wool. Because of using the pool, members conservatively saved over $9,000 in transportation costs. Due to economies of scale realized by selling in a large lot, the pool marketed the wool for 10 percent more than they would have individually. After administrative fees, Front Line Wool pool members realized an additional income of 25 percent in the value of their wool clip.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources

301	Reproductive Performance of Animals
302	Nutrient Utilization in Animals
303	Genetic Improvement of Animals
305	Animal Physiological Processes
306	Environmental Stress in Animals
308	Improved Animal Products (Before Harvest)
311	Animal Diseases
312	External Parasites and Pests of Animals
315	Animal Welfare/Well-Being and Protection
603	Market Economics
604	Marketing and Distribution Practices
722	Zoonotic Diseases and Parasites Affecting Humans
902	Administration of Projects and Programs
903	Communication, Education, and Information Delivery

Outcome #3

1. Outcome Measures

Identification of critical infection and disease resistance

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	25

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Infection and disease factors affecting the nutrition, health and reproductive performance of livestock animals underpin the economic performance of all livestock operations (and is particularly costly in the dairy industry). These infections and diseases are increasingly becoming zoonotic, with growing mortality rates in humans and livestock. Most are born during early reproductive and neonatal stages of livestock. Identifying emerging antibiotic resistance infection and disease is of critical importance to the healthy and safety of a global food supply for producers to maintain safe, efficient and high-value livestock operations.

What has been done
Researchers determined the composition of cattle and sheep vaginal microbiota co-vary with reproductive performance and determined the routes of transmission of early colonizing microbiota in livestock. Mouse models of Staphylococcus aureus mastitis were developed so that researchers can isolate and understand how mastitic cows impact the outcome of mammary gland infection. Several programs to investigate the role of innate immune parameters in bovine host defense were developed.

Results
Substantial progress was made in understanding the role of innate immune parameters in bovine host defense, including factors important for recruitment of phagocytes to the mammary gland during host defense and tissue damage. Physiologically-relevant mouse models were created and studied in order to study the immune responses induced during mastitis. Routes of transmission of early colonizing microbiota in livestock were identified, and correlated with indicators of reproductive performance, neonatal health and livestock performance. New virulence factors and protective antigens for the development of an effective strangles vaccine were identified. Data was collected and analyzed to establish characteristics of colonization strains and asses the risk of colonization in the development of a disease in both humans and livestock.

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of Animals
303	Genetic Improvement of Animals
305	Animal Physiological Processes
307	Animal Management Systems
308	Improved Animal Products (Before Harvest)
311	Animal Diseases
312	External Parasites and Pests of Animals
315	Animal Welfare/Well-Being and Protection
722	Zoonotic Diseases and Parasites Affecting Humans
903	Communication, Education, and Information Delivery

Outcome #4

1. Outcome Measures

Number of improvements in vaccines developed

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Infectious diseases cause considerable loss for livestock producers by reducing production of animal units and reducing sales due to food safety concerns. Increasingly, many of these diseases and infections are becoming zoonotic and antibacterial resistant. MSU is the only land-grant institution in Montana focused on the relationship between human and animal health and in particular, the study of infectious diseases of cattle, bison and sheep. Many effective vaccines are also lacking for many of the disease agents.

What has been done
Largely, research advancements made in vaccine improvement were concentrated in the molecular pathogenesis of West Nile Virus, Genome editing through the use of CRISPER technology and mucosal immunology. Researchers used innate immune system adjuvants as countermeasures against Salmonellosis in claves by conducting in-vitro studies of bovine immune cells. The spread of West Nile virus was examined by understanding the spread of the disease within neurons correlating with the pathogenic outcomes of neuroinvasive diseases observed during interspecies transmission. Researchers defined the effects of immune modulators and tested their effectiveness. Researchers also defined the innate immune responses against pulmonary pathogens and bacterium.

Results
These studies primarily provided insight and critical progress into the basic mechanisms of host defenses within the lungs and gut through (where most early infection pathogens begin) scholarly discovery and dissemination of science and technology related to vaccine development. Knowledge gained and research advancements were made in developing new scientific objectives and discovery in the development of new drugs, vaccines, and diagnostic tools for fighting infectious diseases of livestock, humans and wildlife. Research advancements were made in infectious disease ecology and pathogen spillover in: salmonella infection of the intestinal mucosa, dendritic cells of Helicobacter suis infection in pigs, domestic and wild bighorn sheep pneumonia, pulmonary immunology on viral diseases of the lung, molecular pathogenesis of West Nile virus, genome editing - all either directly a product of, or related to, the development of effective and inexpensive adjuvant therapy for cattle and humans (vaccines) that can be used to help mitigate the impact of these current and emerging diseases.

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of Animals
302	Nutrient Utilization in Animals

303	Genetic Improvement of Animals
305	Animal Physiological Processes
306	Environmental Stress in Animals
308	Improved Animal Products (Before Harvest)
311	Animal Diseases
312	External Parasites and Pests of Animals
315	Animal Welfare/Well-Being and Protection
722	Zoonotic Diseases and Parasites Affecting Humans
903	Communication, Education, and Information Delivery

Outcome #5

1. Outcome Measures

Identification of genetic correlations and other factors influencing residual feed intake and feed efficiency; and education of producers and industry leaders with the latest scientific information

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	20

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Genetic improvement of livestock has been very successful in improving the production and profitability of livestock. This success has been limited in the traits that are difficult or expensive to measure such as reproductive efficiency, longevity, and feed efficiency. Reproductive efficiency and fertility are of major consequence in the sustainability and profitability of livestock production systems. Montana ranchers need to keep pace with market quality demands in beef quality, which comes from investigating and selecting highly-demanded genetic markers.

What has been done
Research was primarily conducted to determine the underlying physiological mechanism which explain the variation in the economically important traits of animal reproduction and feed efficiency. MSU has instigated both long-term breeding projects in Red Angus cattle and Rambouillet sheep, both selected for their distinctive population traits and genetic markers. Gene expression patterns in reproductive tissues and altered physiology that can provide candidate

gene markers and genes for the improvement of cattle and sheep and other livestock species were identified.

Results
Materials were published that discussed the difference in reproductive efficiency seen in sheep, selected for high and low reproduction and the related vaginal microbiome. New studies were initiated that elucidate the molecular mechanisms that underpin variation in livestock feed efficiency and contribute to the development of biologically-based predictors that can improve the accuracy and reliability of genetic selection and improvement in feed efficiency in sheep and cattle. Researchers investigated molecular modifications that promoted the different physiological responses (and therefore will dictate) how animal productivity will occur. This includes; investigating prolonged changes in maternal feed intake during pregnancy, fetal brain development, and the role in controlling how energy utilization and feed intake of offspring will occur late in life. An experiment was initiated that aims to determine the influence of supplemental protein during gestation on fetal and maternal physiology.

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of Animals
302	Nutrient Utilization in Animals
303	Genetic Improvement of Animals
305	Animal Physiological Processes
308	Improved Animal Products (Before Harvest)
315	Animal Welfare/Well-Being and Protection
603	Market Economics
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
903	Communication, Education, and Information Delivery

Outcome #6

1. Outcome Measures

Conduct basic and applied infectious disease research -Increase the quality of meat, milk and fiber products -Reduce non-predator deaths in calves

Not Reporting on this Outcome Measure

Outcome #7

1. Outcome Measures

Add value to Montana beef cattle through nutrition and management methods

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
In Montana, winter feeding concentrates beef cattle for about 4-6 months, and is the biggest and most variable cost for producers. Many cattle producers in Montana rely on supplementation to correct nutritional deficiencies, improve forage utilization and animal performance while increasing economic returns. Monitoring metabolic rates and nutrition of livestock during the winter months provide measures to decrease animal stress and support overall well-being of healthy immune responses. Evaluating opportunities to increase the value of beef cattle in Montana include examining new feed sources and co-products for backgrounding and finishing diets.

What has been done
Through rudimentary economic analysis, aboveground forage production was examined by integrating livestock into cover crop rotations. Physiological responses of cattle were measured during changing seasons and adjusted to feeding levels during Montana winter (when producers feed hay, instead of grazing livestock). Preliminary trials were conducted in both, by systematically lowering and then increasing feed levels. Supplements were provided to grazing beef cattle during times of low forage. Statewide forage interpretation and analysis testing and meetings were held; associated cattle knowledge and behavior changes will be measured to discover the impacts of the workshops.

Results
Supplementation nutrients were found to improve animal performance and provide increased economic returns. Five county agents were trained to use ration balancing software. Scientific discovery and dissemination expanded on the determination of how the basic process of controlling forage intake and utilization by ruminants can be manipulated by supplementation, and how supplement delivery methods affect variation in individual animal consumption management. Management strategies were developed that resulted in improved nutritional efficiency of forage-based diets for livestock. Measures of animal stress and well-being were characterized, including the identification of factors affecting the biology and stress of cattle immune responses.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
302	Nutrient Utilization in Animals

305	Animal Physiological Processes
306	Environmental Stress in Animals
307	Animal Management Systems
308	Improved Animal Products (Before Harvest)
315	Animal Welfare/Well-Being and Protection
902	Administration of Projects and Programs
903	Communication, Education, and Information Delivery

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
- Populations changes (immigration, new cultural groupings, etc.)
- Other (high cost of fuel, fertilizer)

Brief Explanation

Market value for beef cattle has decreased. Montana ranchers continue to adapt to increasing wildlife predator encounters along the urban/wildlife interface as they find methods to protect livestock health and manage to mitigate wildlife encounters that cause livestock mortality. A warming climate affects livestock production as does the national economy and emerging zoonotic diseases and additional health-related issues, as more people become interested in growing their own food, or become concerned about how their food is grown. The generational shift as the population changes is also a factor. Extension and MAES play a stabilizing role in the industry as they seek proactive solutions, and provide unbiased, science-based information for Montana ranchers to remain sustainable and viable.
COA/MAES and Extension did not report on "Conduct basic and applied infectious disease research -Increase the quality of meat, milk and fiber products -Reduce non-predator deaths in calves" as those outcomes have been assigned to their own respective outcomes in varying planned programs. As a singular outcome, it is redundant to several additional outcomes already in Animal Sciences. In short, it is a poorly written outcome as it restates what is already being comprehensively reported in this annual report.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

- Studies primarily provided insight and critical progress into the basic mechanisms of host defenses within the lungs and gut through (where most early infection pathogens begin) scholarly discovery and dissemination of science and technology related to vaccine development.
- Knowledge gained and research advancements were made in developing new scientific

objectives and discovery in the development of new drugs, vaccines, and diagnostic tools for fighting infectious diseases of livestock, humans and wildlife.

- Research advancements were made in infectious disease ecology and pathogen spillover in: salmonella infection of the intestinal mucosa, dendritic cells of Helicobacter suis infection in pigs, domestic and wild bighorn sheep pneumonia, pulmonary immunology on viral diseases of the lung, molecular pathogenesis of West Nile virus, genome editing - all either directly a product of, or related to, the development of effective and inexpensive adjuvant therapy for cattle and humans (vaccines) that can be used to help mitigate the impact of these current and emerging diseases.
- Supplementation nutrients were found to improve animal performance and provide increased economic returns.
- Five county agents were trained to use ration balancing software.
- Scientific discovery and dissemination expanded on the determination of how the basic process of controlling forage intake and utilization by ruminants can be manipulated by supplementation, and how to supplement delivery methods affect variation in individual animal consumption management. Management strategies were developed that resulted in improved nutritional efficiency of forage-based diets for livestock.
- Measures of animal stress and well-being were characterized, including the identification of factors affecting the biology and stress of cattle immune responses.
- Materials were published that discussed the difference in reproductive efficiency seen in sheep, selected for high and low reproduction and the related vaginal microbiome.
- New studies were initiated that elucidate the molecular mechanisms that underpin variation in livestock feed efficiency and contribute to the development of biologically based predictors that can improve the accuracy and reliability of genetic selection and improvement in feed efficiency in sheep and cattle. Researchers investigated molecular modifications that promoted the different physiological responses (and therefore will dictate) how animal productivity will occur.
- This includes; understanding investigating prolonged changes in maternal feed intake during pregnancy, fetal brain development, and the role in controlling how energy utilization and feed intake of offspring will occur late in life.
- An experiment was initiated that aims to determine the influence of supplemental protein during gestation on fetal and maternal physiology.
- Substantial progress was made in understanding the role of innate immune parameters in bovine host defense, including factors important for recruitment of phagocytes to the mammary gland during host defense and tissue damage.
- Physiologically-relevant mouse models were created and studied in order to study the immune responses induced during mastitis.
- Routes of transmission of early colonizing microbiota in livestock were identified, and correlated with indicators of reproductive performance, neonatal health and livestock performance.
- New virulence factors and protective antigens for the development of an effective strangles vaccine were identified.
- Data was collected and analyzed to establish characteristics of colonization strains and asses the risk of colonization in the development of a disease in both humans and livestock.

Key Items of Evaluation

Made a meaningful difference in the way Montana producers understand and manage animal health diseases.
Provided timely information on current and emerging diseases between animals and humans and the potential affects of such on a global food supply.

Developed new vaccines to emerging antibiotic resistant diseases is animals.
Identified new challenges in livestock neonatal health and livestock reproductive performance.
Faculty used new technologies to study the genetic traits that provide the most economic market value for livestock markets, including traits that directly affect weaning weight and reproductive performance.
Researchers identified new and novel ways to encourage livestock to gain weight and eat more protein during critical stress periods in their life cycle.
Researchers found new ways to study cattle immune responses and understand the effect of their stress hormones on carcass composition.
New students and future scientists were trained and mentored in the important role of animal health in global food supply and security.
Researchers developed and researched supplements for livestock that allow nutrient absorption to occur at a more successful rate.
Montana producers were provided information on how to balance feed and nutrient assets for cattle during the winter.
Knowledge was gained and research advancements were made in developing new scientific objectives and discovery in the development of new drugs, vaccines, and diagnostic tools for fighting infectious diseases of livestock, humans and wildlife.

V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

Plant and Soil 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
102	Soil, Plant, Water, Nutrient Relationships	10%		10%	
104	Protect Soil from Harmful Effects of Natural Elements	5%		4%	
111	Conservation and Efficient Use of Water	0%		7%	
112	Watershed Protection and Management	10%		5%	
121	Management of Range Resources	10%		9%	
132	Weather and Climate	10%		5%	
201	Plant Genome, Genetics, and Genetic Mechanisms	0%		8%	
202	Plant Genetic Resources	0%		5%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants	0%		5%	
204	Plant Product Quality and Utility (Preharvest)	10%		7%	
205	Plant Management Systems	10%		5%	
206	Basic Plant Biology	0%		5%	
502	New and Improved Food Products	0%		7%	
503	Quality Maintenance in Storing and Marketing Food Products	0%		3%	
601	Economics of Agricultural Production and Farm Management	15%		3%	
607	Consumer Economics	0%		1%	
701	Nutrient Composition of Food	0%		6%	
903	Communication, Education, and Information Delivery	20%		5%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	3.0	0.0	110.3	0.0
Actual Paid	4.2	0.0	73.1	0.0
Actual Volunteer	3.3	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**
104660	0	726494	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	3731908	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
94809	0	2875563	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Developed new crops and cultivars suitable to a warmer and drier climate
- Explored the ecological impact of climate change on Montana grazing areas
- Studied the impact of a changing climate on insects
- Continue investigating crops and management systems that rely on less water consumption
- Met one-on-one with producers, landowners and consumers to identify and address individual problems and solutions
- Encouraged email and phone conversations with members of the public
- Offered classes, workshops, group discussions, demonstrations, field tours/trials, webinars
- Shared information at farmer's markets, county fairs and other community events
- Attended and presented information at professional conferences, county meetings and state conventions
- Prepared and distributed public service announcements, newsletters, MONTGuides, Television (Montana PBS Montana Ag Live), eXtension, listservs, blogs, radio and other media
- Created readily available and easily accessible databases for producers and researchers
- Prepared research articles, fact sheets and news releases for scientists and statewide media
- Hosted strategic planning meetings with state agricultural groups and Extension advisory groups
- Developed systems that ensure food safety and agricultural security
- Supported FIFRA Section 18c products labeling requests
- Released germplasm, new cultivars, and new genomics tools and techniques
- Developed value-added, agriculturally based end-use products
- Enhanced partnerships among faculty across Montana institutions, producers, agricultural industry and other educational institutions
- Enhanced agricultural production practices to enhance product quality
- Investigated and then educated producers on crops and management systems that consume less water

2. Brief description of the target audience

- Crop and livestock producers
- State agricultural advisory committees
- State and federal government agencies
- Commodity associations
- Weed control professionals and County Weed Boards
- Small acreage landowners
- Tribal councils and Native American producers
- Crop protection companies registration and research personnel
- Private and commercial pesticide applicators
- Domestic and foreign buyers of wheat
- Montana Wheat and Barley Committee, grain elevators operators

3. How was eXtension used?

Extension faculty utilized eXtension to provide webinars and programming, share fact sheets, evaluate courses and programs (Moodle), conduct radio interviews, create Extension documents and as a general resource.

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	10000	211618	5687	5055

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

Patent Applications Submitted

Year:	2016
Actual:	2

Patents listed
PVP201600092 - Wheat, common, "Northern"
PV201600298 - Lanning wheat

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	48	250	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2016	250

Output #2

Output Measure

- Number of producers attending workshops, field days, research plot sites, and research center summaries

Year	Actual
2016	5000

Output #3

Output Measure

- Number of people adopting conservation practices.

Year	Actual
2016	15000

Output #4

Output Measure

- Number of producers using pulse crops in rotation

Year	Actual
2016	15000

Output #5

Output Measure

- Number of people participating in range monitoring programs and the Range Management Institute

Year	Actual
2016	10

Output #6

Output Measure

- Number of requests to identify or record new weeds and pests

Year	Actual
2016	400

Output #7

Output Measure

- Number of foreign trade teams

Year	Actual
2016	16

Output #8

Output Measure

- Number of new wheat lines developed

Year	Actual
2016	2

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Crops: Increase in number of producers who implement nutrient cycling, weed control, variety selection and alternative crop possibilities. Increase in number of farm operators who implement best practices to increase profitability and enhance long-term sustainability
2	Number of new stress tolerant crop recommendations or changes for Montana. Number of new or improved cultivar recommendations provided to Montana producers to maintain dominance in small grain markets
3	Number of new molecular techniques into breeding projects to improve outcomes
4	Increase average per bushel yield of Montana grains while maintaining product quality
5	Increase agricultural resilience to short-term weather fluctuations by improving soil health and minimizing soil erosion.
6	Grow number of LRES graduate student research assistants by 20% over five years

Outcome #1

1. Outcome Measures

Crops: Increase in number of producers who implement nutrient cycling, weed control, variety selection and alternative crop possibilities. Increase in number of farm operators who implement best practices to increase profitability and enhance long-term sustainability

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
In the Western United States, agriculture activities contribute to the majority of the region's total anthropogenic NH3 emissions into the atmosphere. Nitrogen fertility and nitrogen inputs typically represent a grower's largest annual cost. Manure and fertilizer are the primary source of NH3 emissions in this region, causing economic loss to farms, air quality degredation, and N deposition and pollution of natural ecosystems. On-farm management practices that result in the mitigation of NH3 emissions improve crop N efficiency and agricultural sustainability.

What has been done
Gaseous loss of NH3 from fertilizer N applications and legume green manures were measured and quantified. Investigations with other N fertilizer sources and urease inhibitors and NH3 volatilization from legume green manures occurred. Fertilizer recommendations were developed on how N management can be improved to reduce NH3 losses and improve fertilizer N use efficiency for improved profitability and environmental quality. A partial economic analysis was started to help understand the potential benefits of treating urea with thiophosphoric triamide (NBPT).

Results
Measurements of an ammonia volatilization project has garnered considerable interest and support by the agricultural community in Montana. Grower surveys were conducted on the impact of research in production practices. Evaluations from two seminars indicated that 80% of the respondents will likely change a management practice based on what they learned at the seminar and 100% of the respondents said they have learned with at least one other person. Results of surveys, evaluations and discussions with growers indicate this project is having a large impact on growers in this region of Montana. Several growers and crop advisers have told us that they

have changed, or plan to change, their urea management practices to minimize volatilzation, which has likely increased their grain yield, grain protein, and net revenue.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
104	Protect Soil from Harmful Effects of Natural Elements
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
132	Weather and Climate
205	Plant Management Systems
206	Basic Plant Biology
601	Economics of Agricultural Production and Farm Management
903	Communication, Education, and Information Delivery

Outcome #2

1. Outcome Measures

Number of new stress tolerant crop recommendations or changes for Montana. Number of new or improved cultivar recommendations provided to Montana producers to maintain dominance in small grain markets

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	20

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Agriculture is the main economic industry in central Montana. Seeded forages, cereal grains and oilseed crops are economically important to central Montana and across the Northern Great Plains region. Maintaining and improving crop yield and quality is critical to the economic well being of central Montana and elsewhere. Cereal grains and oilseed crops are widely used in foods, feeds, fiber and increasingly, as fuels. The need to identify stress-tolerant and new and improved cereal cultivars is important to not only Montana's primary economic industry, but to the

continuation of a safe and healthy global food supply.

What has been done
New annual and perennial forage species and cultivars for adaptation and performance were identified and examined in field trials across Montana. Improved cultivars of cereals, perennial legumes and perennial grasses were identified and selected improved forage lines were identified by separating winter triticale populations, which will increase forage production quality in rainfed environments. A multi-location canola trial was held, and results were included in the 2013 Montana Statewide Canola Variety Trial Report. Several long-term cropping systems continued in identifying new stress-tolerant crop recommendations to Montana growers.

Results
Applied research results were published and disseminated through field days, on-farm crop tours, grower meetings, Extension publications, and journal articles. 30 perennial grass species were evaluated for forage yield, 40 lines of awnless and reduced-awn winter triticale were evaluated for facultative reproductive nature. A nitrogen rate study on malt barley was completed which helped confirm that MSU recommendation for malt barley production is accurate. Variety development and testing efforts, as well as cropping systems studies will be continued in the next reporting period. New lines of barley were grown in dryland and irrigated conditions. Experiments created defined levels of amylose in both durum and red wheat that have progressed to the identification of combinations of individual lines that impart distinct levels of amylose.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
111	Conservation and Efficient Use of Water
132	Weather and Climate
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)
206	Basic Plant Biology
502	New and Improved Food Products
701	Nutrient Composition of Food
903	Communication, Education, and Information Delivery

Outcome #3

1. Outcome Measures

Number of new molecular techniques into breeding projects to improve outcomes

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The number of new molecular techniques applied to breeding projects improves outcomes for a healthy and safe global food supply and for the designing of new strategies for enhanced ag-related plant development, so that Montana farmers can remain viable. The genetic makeup of every single variety must satisfy the requirements of farmers, millers and bakers and contribute to a global food source and plant breeding scientific community. This year, new tools for surgically manipulating DNA in plant and animal genomes are now available and COA/MAES research has captured outside funding for this vein.

What has been done
An established genome-wide knockout library for phenotypic screening was created. Developed improved cultivars of spring and winter wheat with important agronomic and economic traits for Montana farmers and global markets. Developed efficient screening, selection and breeding strategies and procedures to maximize efficiency and genetic progress in spring and winter wheat breeding programs.

Results
The development and release of an improved winter wheat cultivar, "Loma" was produced in Sept. 2016. Studies were initiated in the management and utilization of plant genetic resources and quantitative genetics and cultivar development. USDA statistics show that Montana planted 5.28 million acres of wheat last year, making it the third-highest state for planted wheat acres in the country. MAES-developed spring and winter wheat varieties accounted for 2.89 million of those acres, or approximately $500 million of $1 billion wheat sold by Montana farmers in 2015, according to MSU wheat breeding specialists. Some wheat varieties developed by MSU are sold by private companies. Montana exports 20 percent of agricultural products as foreign exports and 75 percent of its wheat to Asian markets, according to the USDA. New wheat lines were bred with specific traits that were agronomically and economically viable for producers.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
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)
206	Basic Plant Biology
502	New and Improved Food Products
607	Consumer Economics
701	Nutrient Composition of Food
903	Communication, Education, and Information Delivery

Outcome #4

1. Outcome Measures

Increase average per bushel yield of Montana grains while maintaining product quality

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Montana ranks sixth in the nation for sugarbeet production, the third-highest in the country for wheat production and the first in pulse crop production (pea, lentil and chickpea). Because of the enormous economic benefit from agriculture commodities, it is important for MSU, the state's largest and flagship land-grant institution, to conduct research that benefits the agronomic and economic output of Montana farmers.

What has been done
Investigation of adaptation, genetic diversity, and agronomic practices in Montana and the semiarid U.S. Northern Great Plains were instigated. Outcomes included scholarly research advancements in soil-climatic adaptation and seedling disease management. Diverse cropping systems were evaluated with cropping sequence effects in dryland agriculture systems and genetic variation within winter and spring wheat, canola, lentil, pea and other crops.

Results
Studies reaffirmed the value of mild, dry, conditions during seedling establishment of wheat systems in Montana. The study of the role of alternative plant functional groups in wheat cycles continue to show a significant yield boost when used as a cover-crop treatment or rotational crop. One study is being used in a 2017 thesis publication that shows the effects of cool vs. warm

season cover crops, graze or non-graze terminated on soil properties and subsequent yield and quality at four different Montana locations. Research has continued on long-term organic wheat systems in on-farm locations in Bozeman and farms statewide. Preliminary data from medium-term rotations are showing positive economic results for pea in rotation with wheat, stronger and earlier than was observed in long-term study in the generally wetter and cooler climate of southwestern Montana. Studies continue to measure economic and agronomic gain in Montana grains farming. Montana again was the country's third-highest producer of wheat in 2016, according to the USDA.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
104	Protect Soil from Harmful Effects of Natural Elements
111	Conservation and Efficient Use of Water
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
601	Economics of Agricultural Production and Farm Management
903	Communication, Education, and Information Delivery

Outcome #5

1. Outcome Measures

Increase agricultural resilience to short-term weather fluctuations by improving soil health and minimizing soil erosion.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The ability for future generations of Montana farmers and ranchers largely depends on their ability to mitigate and adapt to climate change and related soil health, by minimizing soil erosion. Local, regional and federal land managers need to identify best-practices that can maximize current returns and lengthen soil carbon residence times and better understand nutrient cycling in agricultural soils; how long soil carbon persists in soil before it is lost from the soil due to erosion, leaching or transformation by soil organisms.

What has been done

Major goals of associated projects include the inventory of soil carbon residence times across southwestern Montana using a state factor approach and identify management practices that can lengthen those soil carbon residence times. In 2016, researchers and graduate students began sampling and producing data for soils and waters within the Gallatin Watershed as part of a collaborative effort to better understand the hydrology of process domain transitions from high elevation mountain catchments to disruptive fluvial systems intermountain valleys such as the Gallatin Valley. A research project was initiated to understand how wheat rotation management impacts evapotranspiration, soil moisture, sensible heat flux and carbon dioxide flux at the scale of a farmer's field using direct measurements, and at the watershed scale using remote sensing.

Results

A protocol for water-induced respiration, where measurements of soil respiration are collected immediately prior and following the experimental addition of water to a soil. This will help clarify some of the driving factors responsible for post-water additions of water to a soil. Spoil and vegetation water flux were linked to atmospheric boundary layer processes, which provided a starting to quantify the role of agricultural management practices away from summer fallow on regional climate in the Northern Great Plains region. Studies will continue to contribute to surface atmosphere flux observations using the eddy covariance technique in dryland wheat/fallow and natural grassland ecosystems and atmospheric boundary layer height observations via ceilometer in order to better understand how agricultural management alters soil and environmental physics to influence atmospheric and climate processes.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
104	Protect Soil from Harmful Effects of Natural Elements
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
132	Weather and Climate
206	Basic Plant Biology
903	Communication, Education, and Information Delivery

Outcome #6

1. **Outcome Measures**

Grow number of LRES graduate student research assistants by 20% over five years

Not Reporting on this Outcome Measure

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
- Other (High cost of fuel, fertilizer)

Brief Explanation

COA/MAES and Extension neglected to report on the previous outcome, "Grow LRES graduate assistantships by 20% over the next five years," as that outcome is not a program associated with direct Hatch-Act research funds within the college, station or Extension. Rather, it is a graduate student recruitment and retention goal managed by institutional programs outside of the college, of which (outside of Hatch-Act and Smith-Lever projects and associated funds) COA/MAES and Extension have no responsibility.
A warming climate, new and emerging pests and diseases due to unpredictable weather patterns, increasingly threatened natural resources, and global wheat markets declining may have affected program outcomes.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Measurements of an ammonia volatilization project has garnered considerable interest and support by the agricultural community in Montana. Grower surveys were conducted on the impact of research in production practices. Evaluations from two seminars indicated that 80% of the respondents will likely change a management practice based on what they learned at the seminar and 100% of the respondents said they have learned with at least one other person. Results of surveys, evaluations and discussions with growers indicate this project is having a large impact on growers in this region of Montana. Several growers and crop advisers have told us that they have changed, or plan to change, their urea management practices to minimize volatilization, which has likely increased their grain yield, grain protein, and net revenue.
Applied research results were published and disseminated through field days, on-farm crop tours, grower meetings, Extension publications, and journal articles. 30 perennial grass species were evaluated for forage yield, 40 lines of awnless and reduced-awn winter triticale were evaluated for facultative reproductive nature. A nitrogen rate study on malt barley was completed which helped confirm that MSU recommendation for malt barley

production is accurate. Variety development and testing efforts, as well as cropping systems studies will be continued in the next reporting period. New lines of barley were grown in dryland and irrigated conditions. Experiments created defined levels of amylose in both durum and red wheat that have progressed to the identification of combinations of individual lines that impart distinct levels of amylose.

New annual and perennial forage species and cultivars for adaptation and performance were identified and examined in field trials across Montana. Improved cultivars of cereals, perennial legumes and perennial grasses were identified and selected improved forage lines were identified by separating winter triticale populations, which will increase forage production quality in rainfed environments. A multi-location canola trial was held, and results were included in the 2013 Montana Statewide Canola Variety Trial Report. Several long-term cropping systems continued in identifying new stress-tolerant crop recommendations to Montana growers.
New annual and perennial forage species and cultivars for adaptation and performance were identified and examined in field trials across Montana. Improved cultivars of cereals, perennial legumes and perennial grasses were identified and selected improved forage lines were identified by separating winter triticale populations, which will increase forage production quality in rainfed environments. A multi-location canola trial was held, and results were included in the 2013 Montana Statewide Canola Variety Trial Report. Several long-term cropping systems continued in identifying new stress-tolerant crop recommendations to Montana growers.

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An established genome-wide knockout library for phenotypic screening was created. Developed improved cultivars of spring and winter wheat with important agronomic and economic traits for Montana farmers and global markets. Developed efficient screening, selection and breeding strategies and procedures to maximize efficiency and genetic progress in spring and winter wheat breeding programs.
Investigation of adaptation, genetic diversity, and agronomic practices in Montana and the semiarid U.S. Northern Great Plains were instigated. Outcomes included scholarly research advancements in soil-climatic adaptation and seedling disease management. Diverse cropping systems were evaluated with cropping sequence effects in dryland agriculture systems and genetic variation within winter and spring wheat, canola, lentil, pea and other crops.

The development and release of an improved winter wheat cultivar, "Loma" was produced in Sept. 2016. Studies were initiated in the management and utilization of plant genetic resources and quantitative genetics and cultivar development. USDA statistics show that

Montana planted 5.28 million acres of wheat last year, making it the third-highest state for planted wheat acres in the country. MAES-developed spring and winter wheat varieties accounted for 2.89 million of those acres, or approximately $500 million of $1 billion wheat sold by Montana farmers in 2015, according to MSU wheat breeding specialists. Some wheat varieties developed by MSU are sold by private companies. Montana exports 20 percent of agricultural products as foreign exports and 75 percent of its wheat to Asian markets, according to the USDA. New wheat lines were bred with specific traits that were agronomically and economically viable for producers.
A protocol for water-induced respiration, where measurements of soil respiration are collected immediately prior and following the experimental addition of water to a soil. This will help clarify some of the driving factors responsible for post-water additions of water to a soil. Spoil and vegetation water flux were linked to atmospheric boundary layer processes, which provided a starting to quantify the role of agricultural management practices away from summer fallow on regional climate in the Northern Great Plains region. Studies will continue to contribute to surface atmosphere flux observations using the eddy covariance technique in dryland wheat/fallow and natural grassland ecosystems and atmospheric boundary layer height observations via ceilometer in order to better understand how agricultural management alters soil and environmental physics to influence atmospheric and climate processes.
Major goals of associated projects include the inventory of soil carbon residence times across southwestern Montana using a state factor approach and identify management practices that can lengthen those soil carbon residence times. In 2016, researchers and graduate students began sampling and producing data for soils and waters within the Gallatin Watershed as part of a collaborative effort to better understand the hydrology of process domain transitions from high elevation mountain catchments to disruptive fluvial systems intermountain valleys such as the Gallatin Valley. A research project was initiated to understand how wheat rotation management impacts evapotranspiration, soil moisture, sensible heat flux and carbon dioxide flux at the scale of a farmer's field using direct measurements, and at the watershed scale using remote sensing.

Key Items of Evaluation

MSU faculty scientists met with statewide farmers to discuss needs for best yields and management of emerging pests and diseases in grains.
MAES-developed spring and winter wheat varieties accounted for 2.89 million of those acres, or approximately $500 million of $1 billion wheat sold by Montana farmers in 2015, according to MSU wheat breeding specialists. Some wheat varieties developed by MSU are sold by private companies. Montana exports 20 percent of agricultural products as foreign exports and 75 percent of its wheat to Asian markets, according to the USDA. New wheat lines were bred with specific traits that were agronomically and economically viable for producers.
MSU wheat breeders filed for two patents for two new releases of wheat that reflect varieties Montana soil, climatic and water prescriptions.
MSU developed new annual and perennial forage cultivars so that Montana farmers and ranchers have a reliable and safe means to feed livestock through the winter months.
Studies confirmed the value of mild, dry conditions during seeding of wheat systems in Montana and the impact of pulse crops as a rotational and cover crop in wheat systems. Montana again was the nation's top producer of pulse crops in the country in 2016.
A nitrogen rate study on malt barley was completed which helped confirm that MSU recommendation for malt barley production is accurate.
New annual and perennial forage species and cultivars for adaptation and performance were identified and examined in field trials across Montana. Improved cultivars of cereals,

perennial legumes and perennial grasses were identified and selected improved forage lines were identified by separating winter triticale populations, which will increase forage production quality in rainfed environments.
Research has continued on long-term organic wheat systems in on-farm locations in Bozeman and farms statewide. Preliminary data from medium-term rotations are showing positive economic results for pea in rotation with wheat, stronger and earlier than was observed in long-term study in the generally wetter and cooler climate of southwestern Montana.
Studies continue to measure economic and agronomic gain in Montana grains farming. Montana again was the country's third-highest producer of wheat in 2016, according to the USDA.
An established genome-wide knockout library for phenotypic screening was created.
Developed improved cultivars of spring and winter wheat with important agronomic and economic traits for Montana farmers and global markets. In 2016, MSU-MAES wheat varieties accounted for 2.3/5.287 million planted acres, totaling $500 million/ $1 billion of wheat sold by Montana farmers.
The development and release of an improved winter wheat cultivar, "Loma" was produced in Sept. 2016.
Major goals of associated projects included the inventory of soil carbon residence times across southwestern Montana using a state factor approach and identify management practices that can lengthen those soil carbon residence time.

V(A). Planned Program (Summary)

Program # 3

1. Name of the Planned Program

Farm, Ranch and Business Management

☑ 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
112	Watershed Protection and Management	5%		0%	
121	Management of Range Resources	5%		0%	
307	Animal Management Systems	5%		0%	
601	Economics of Agricultural Production and Farm Management	30%		45%	
602	Business Management, Finance, and Taxation	5%		20%	
609	Economic Theory and Methods	5%		12%	
610	Domestic Policy Analysis	5%		9%	
611	Foreign Policy and Programs	0%		9%	
903	Communication, Education, and Information Delivery	40%		5%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	1.5	0.0	13.5	0.0
Actual Paid	3.5	0.0	5.8	0.0
Actual Volunteer	0.1	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**
75868	0	80199	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	365142	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
168592	0	193994	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

COA, MAES and Extension worked one-on-one and in groups with producers, landowners and consumers to identify and address individual and industry challenges and solutions. They conducted research on the impact of federal domestic and international agriculture policy and communicated those potential affects directly to landowners and through scholarship. They answered specific questions through workshops, phone calls, email and personal consultations. Faculty offered classes, workshops, group discussions, demonstrations, field tours/trials and more. Agents, specialists and volunteers disseminated knowledge at every available chance via community events and meetings. MSU Extension utilized PSA's, newsletters, MontGuides, television, eXtension, listserves and other media. Additional priorities included:

- Publish peer reviewed articles contributing to the field in relation to important federal and global agricultural market and policy trends that direct affect Montana producers
- Create and maintain outreach programs
- Provide improved information and research in relation to farm, ranch and agribusiness management
- Contribute to the understanding of financial and management decisions
- Provide informational training and programs related to the environment

2. Brief description of the target audience

- Farmers/Ranchers/Ag producers
- Land Managers/Owners
- Livestock/Crop producers and related stakeholders
- Private forest land owners and public land managers
- Small acreage land owners
- Tribal farm and ranch managers
- Agribusiness owners and managers
- Agricultural educators

3. How was eXtension used?

eXtension was used for general resources and for planning and evaluation tools. Specialists answer questions that are asked through "Ask an Expert".

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	2720	13424	160	300

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

Patent Applications Submitted

Year: 2016

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	25	32	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Provide transformational research and education to producers through outreach and Extension programs.

Year	Actual
2016	35

Output #2

Output Measure

- Publish research in peer-reviewed, scientific journals

Year	Actual
2016	32

Output #3

Output Measure

- Present research findings to the public and interested producers through seminars and

workshops

Year	Actual
2016	5000

Output #4

Output Measure

- Support creation of new value-added agricultural business opportunities for rural communities

Year	Actual
2016	25

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of new or improved management recommendations provided to and adopted by Montana producers.
2	Increase in number of producers, small and large acreage landowners who are aware of current programs and information related to farm and ranch business management, and make timely management decisions as a result.
3	Increase in number of producers/farm and ranch managers who implement range monitoring activities which lead to improvement in resource management strategies.
4	Provide market analysis of trade and marketing in dynamic markets

Outcome #1

1. Outcome Measures

Number of new or improved management recommendations provided to and adopted by Montana producers.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	13835

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
MSU Extension economists work together with MSU College of Agriculture economists to provide Montana stakeholders with tools and resources to enable them to best manage their farms and ranches. Issues they tackle are generally stakeholder and/or market driven. Recently many consumers have had questions about Agricultural Land Leasing, the desire for innovative Ag Econ outreach tools, insurance, estate planning and more. Recent decreases in commodity prices has increased the necessity of good decision making to remain profitable.

What has been done
MSU Extension and COA economists created a website for Agricultural Land Leasing (www.msuextension.org/aglease) that includes lease rates and resources. The website had 3,344 page views. A series of workshops reached 548 individuals. AgEconMT.com was created to give stakeholders up-to-date economic analysis, news and reports to make more informed decisions. The site had 7,683 page views from August through December. Twelve seminars were completed to inform non-farm, non-rural residents of the importance of Ag to the Montana economy. Farm Service Administration Borrower Training was conducted reaching 20 students. Additional classes were held related to marketing and estate planning and financial and production record keeping.

Results
Ag Land Leasing classes were rated an average of 4.4/5. Of Extension faculty taking the class, 100% were more confident helping clients set a stocking rate for grazing leases, describing the advantages and disadvantages of crop share leases and answering client questions about how state, Forest Service and BLM grazing leases are derived and administered. 100% were more inclined to emphasize the importance of record-keeping to establish appropriate lease values. At Bovine Connection workshops (partnership with NDSU Extension), 94% of attendees said they would use information in their future decision making. Following an estate planning workshop, 22

producers reached out to Extension to get started with their estate plans, ensuring that these farms and ranches will successfully transfer to the next generation. Following a marketing workshop, participants indicated they had more options and choices to help them when selling their calves. One producer later noted that they increased their bottom line by $1/hundred weight as a result. On the Blackfeet Reservation, 190 producers received $1.74 million in various benefits in part because they had good production and financial records.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
602	Business Management, Finance, and Taxation
609	Economic Theory and Methods
610	Domestic Policy Analysis
611	Foreign Policy and Programs
903	Communication, Education, and Information Delivery

Outcome #2

1. Outcome Measures

Increase in number of producers, small and large acreage landowners who are aware of current programs and information related to farm and ranch business management, and make timely management decisions as a result.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Agricultural producers and agribusinesses are both positively and negatively affected by supply, demand, technology, market integration, risk management and international trade dynamics. Research in Agricultural Economics provides objective, research-based, economic information regarding the impacts of changes in market and policy conditions on the agricultural food and fiber sector to agricultural producers and agribusiness and communities across Montana.

What has been done
Estimations were provided of farm-level debt levels. Studies showed that farmers likely use annual decoupled payments to reduce their debt, potentially influencing their exposure to financial risks, capacity to withstand financial instability, and access to credit. Changes enacted in the 2014 Farm Bill may diminish farmers' abilities to remain liquid in financially stressful periods.

Results
Results of wheat cropping systems intensification indicates that if no structural market shifts occur to increase the demand for camelina and/or production practices and camelina yields remain similar to those in the trials, there is a low likelihood that camelina market prices would be sufficiently high to incentivize widespread adoption. Research results show....

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
601	Economics of Agricultural Production and Farm Management
602	Business Management, Finance, and Taxation
609	Economic Theory and Methods
610	Domestic Policy Analysis
611	Foreign Policy and Programs
903	Communication, Education, and Information Delivery

Outcome #3

1. Outcome Measures

Increase in number of producers/farm and ranch managers who implement range monitoring activities which lead to improvement in resource management strategies.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	622

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Herbicides have been widely used to suppress spotted knapweed, a noxious weed that infests thousands of acres on the Flathead Reservation, and millions of acres throughout North America. However, herbicide control is expensive and must often be reapplied every three to five years. In response to the high costs, environmental concerns and health risks surrounding herbicides, the Confederated Salish and Kootenai Tribe (CSKT) and MSU have been working together for the past seven years to explore alternatives. Across the state, Extension is working with landowners on range-monitoring exercises.

What has been done
The Knapweed research project is in the fourth and final year. Currently the study is examining the combined use of targeted cattle grazing and bio-control insects at a site on CSKT tribal lands near Buffalo Bridge, southwest of Polson. Field work was ongoing from 2013 to 2016. Two strategies to increase cattle consumption of spotted knapweed without harming the native grasses and wildflowers, and without harming the bio-control insects that already inhabit the site were tested. These were: diet training and high stock-density grazing. The bio-control insects that were utilized fed on the leaves and seeds (Larinus) and roots (Cyphocleonus and Agapeta) of the knapweed plant.

Results
Data analysis is still underway, however preliminary results indicate that targeted cattle grazing and bio-control insects work well together. Diet training was not found to increase cattle preference of spotted knapweed and targeted grazing was effective with or without diet training. After three years, targeted cattle grazing with bio-control insects decreased spotted knapweed plant density 66% (from 56.5 to 19.2 plants/m2). There were 26% fewer spotted knapweed plants than with bio-control insects alone. Following a workshop in another area, one producer was inspired to try a cover crop in their grazing system and reported later that having the cover crop (under irrigation) saved him one month of feeding hay over the fall. After another workshop, participants realized they tended to fall into routine when deciding on pastures/fields to use. They learned the importance of strategic pasture rotation and how it is good for the health of the pasture, the nutritional needs of the cattle and the bottom line.

4. Associated Knowledge Areas

KA Code	Knowledge Area
121	Management of Range Resources
307	Animal Management Systems
601	Economics of Agricultural Production and Farm Management
903	Communication, Education, and Information Delivery

Outcome #4

1. Outcome Measures

Provide market analysis of trade and marketing in dynamic markets

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	6

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Agricultural producers and agribusinesses are both positively and negatively affected by supply, demand, technology, market integration, risk management and international trade dynamics. Producers need to be equipped with objective, research-based, economic information regarding the impacts of changes in market and policy conditions on the agricultural food and fiber sector.

What has been done
Market supply was estimated by statistical and simulation procedures that estimated demand, price margin, weather, and basis relationships related to domestic agricultural commodity, product, and input markets. Producer opportunities were evaluated on agribusiness opportunities, market access, market structure, specialty crops, and food technology issues. The performance of risk management tools included commodities futures/options markets, insurance, contracting, and diversification used by agricultural producers and agribusinesses.

Results
Application of these methods to the pertinent problems will provide valuable information for public policy purposes and information for individual producer risk management, marketing, and product identity decisions. Estimation results on farm-level debt indicate a negative and statistically significant relationship between changes in decoupled payment receipts and farm-level debt levels. This implies that farmers likely used decoupled payments to reduce their debt, potentially influencing their exposure to financial risks, capacity to withstand financial instability and access to credit. Therefore, changes to these policies, such as those that were enacted in the 2014 Farm Bill, may diminish farmers' abilities to remain liquid in financially stressful periods.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
602	Business Management, Finance, and Taxation
609	Economic Theory and Methods
610	Domestic Policy Analysis
903	Communication, Education, and Information Delivery

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

Brief Explanation

In Montana and throughout the United States, market conditions, government policy and international and domestic policy decisions and fluctuations affect every aspect of agricultural and natural resource economic activity and, directly and indirectly, all aspects of the lives of people who live in rural communities. These policies have impacts on consumer welfare, producer welfare and the welfare of farm input suppliers and food processors, rural communities and taxpayers.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

MSU Extension and COA economists created a website for Agricultural Land Leasing (www.msuextension.org/aglease) that includes lease rates and resources. The website had 3,344 page views. A series of workshops reached 548 individuals. AgEconMT.com was created to give stakeholders up-to-date economic analysis, news and reports to make more informed decisions. The site had 7,683 page views from August through December. Twelve seminars were completed to inform non-farm, non-rural residents of the importance of Ag to the Montana economy. Farm Service Administration Borrower Training was conducted reaching 20 students. Additional classes were held related to marketing and estate planning and financial and production record keeping.
Ag Land Leasing classes were rated an average of 4.4/5. Of Extension faculty taking the class, 100% were more confident helping clients set a stocking rate for grazing leases, describing the advantages and disadvantages of crop share leases and answering client questions about how state, Forest Service and BLM grazing leases are derived and administered. 100% were more inclined to emphasize the importance of record-keeping to establish appropriate lease values. At Bovine Connection workshops (partnership with NDSU Extension), 94% of attendees said they would use information in their future decision making. Following an estate planning workshop, 22 producers reached out to Extension to get started with their estate plans, ensuring that these farms and ranches will successfully transfer to the next generation.
Market supply was estimated by statistical and simulation procedures that estimated demand, price margin, weather, and basis relationships related to domestic agricultural commodity, product, and input markets. Producer opportunities were evaluated on agribusiness opportunities, market access, market structure, specialty crops, and food technology issues. The performance of risk management tools included commodities futures/options markets, insurance, contracting, and diversification used by agricultural producers and agribusinesses.

Key Items of Evaluation

Agricultural producers and agribusinesses are both positively and negatively affected by supply, demand, technology, market integration, risk management and international trade dynamics. Research in Agricultural Economics provides objective, research-based, economic information regarding the impacts of changes in market and policy conditions on the agricultural food and fiber sector to agricultural producers and agribusiness and communities across Montana. At every turn, MSU COA/MAES faculty and Extension personnel conduct research in agricultural economics, business and policy that directly affect Montanans working in agriculture. For 2016, the results of federal funding allowed Montana producers to tailor their output costs, financing and planning for the best on-farm and ranch suitability.

COA/MAES and Extension faculty again supported Montanans in managing their farms, ranches and similar enterprises as businesses in 2016. Collectively, the faculty capacity ensured best practices, contracts and estate planning, marketing from an ag perspective, taxation, accounting, operational planning, budgeting, agricultural policy and commodity support programs, risk management and decision support software for Montana. MSU Extension faculty and specialists ensured Montana producers understood implications and changes within the 2014 Farm Bill and MSU agricultural economics faculty continued evaluating, engaging and researching federal agricultural policy that directly affects regional producers.
MSU Extension economists work together with MSU College of Agriculture economists to provide Montana stakeholders with tools and resources to enable them to best manage their farms and ranches. Issues they tackle are generally stakeholder and/or market driven. Recently many consumers have had questions about Agricultural Land Leasing, the desire for innovative Ag Econ outreach tools, insurance, estate planning and more. Recent decreases in commodity prices has increased the necessity of good decision making to remain profitable.

COA/MAES and Extension most notably provided Montanans with:
Distilled and meaningful tools and information borne at the national level, in legislation, policy and programs that directly affect Montanans working in agriculture.
A new website from Agricultural Economics faculty that provides weekly and monthly content tailored for Montana markets.
Increased number of producers, small and large acreage landowners who are aware of current programs and information related to farm and ranch business management, and make timely management decisions as a result.
Estimations were provided of farm-level debt levels. Studies showed that farmers likely use annual decoupled payments to reduce their debt, potentially influencing their exposure to financial risks, capacity to withstand financial instability, and access to credit. Changes enacted in the 2014 Farm Bill may diminish farmers' abilities to remain liquid in financially stressful periods.

Additionally, Farm and Ranch Management results were garnered within:

- Appraisal of Soil Resources
- Conservation of Efficient Use of Water
- Watershed Protection and Management
- Management of Range Resources
- Management and Control of Forest and Range Fires
- Weather and Climate
- Conservation of Biological Diversity
- Animal Management Systems
- Economics of Agricultural Production
- Business Management, Finance and Taxation
- Economic Theory and Methods
- Domestic Policy Analysis
- Foreign Policy and Programs

V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Integrated Pest Management

☑ 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
211	Insects, Mites, and Other Arthropods Affecting Plants	0%		15%	
212	Diseases and Nematodes Affecting Plants	10%		6%	
213	Weeds Affecting Plants	15%		10%	
214	Vertebrates, Mollusks, and Other Pests Affecting Plants	0%		6%	
215	Biological Control of Pests Affecting Plants	15%		10%	
216	Integrated Pest Management Systems	25%		15%	
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals	0%		5%	
601	Economics of Agricultural Production and Farm Management	5%		3%	
603	Market Economics	0%		3%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources	5%		5%	
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins	0%		5%	
721	Insects and Other Pests Affecting Humans	0%		10%	
903	Communication, Education, and Information Delivery	25%		7%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	3.0	0.0	62.0	0.0
Actual Paid	8.9	0.0	78.1	0.0

Actual Volunteer	0.1	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**
131261	0	788418	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	3032966	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
317965	0	3003409	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

• Met one-on-one with producers, landowners and consumers to identify and address individual problems and solutions
• Encouraged email and phone conversations with members of the public
• Offered classes, workshops, group discussions, demonstrations, field tours/trials, webinars
• Shared information at farmer's markets, county fairs and other community events
• Attended and presented information at professional conferences, county meetings and state conventions
• Prepared and distributed public service announcements, newsletters, MONTGuides, Television (Montana PBS Montana Ag Live), eXtension, listservs, social media, radio and other media
• Created readily available and easily accessible databases for producers and researchers
• Prepared research articles, fact sheets and news releases for scientists and statewide media
• Hosted strategic planning meetings with state agricultural groups
• Developed systems that ensure food safety and agricultural security
• Integrated best practices for pests and disease management in parallel programs

2. Brief description of the target audience

• Agricultural producers in Montana facing current and future threats relating to invasive plants, plant diseases and pests.
• University faculty scientists conducting research in IPM
• Extension outreach personnel and statewide agents
• University economic development research programs
• Montana USDA state statistician and agricultural economics faculty
• Montana grain producers and associated committees, groups, and boards

3. How was eXtension used?

eXtension was used for evaluation and planning tools.

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	31573	33345	5569	3500

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

Patent Applications Submitted

Year:	2016
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	66	250	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Identify critical infection and disease resistance

Year	Actual
2016	45

Output #2

Output Measure

- Number of samples processed by Schutter Diagnostic Laboratory.

Year	Actual
2016	3514

Output #3

Output Measure

- Number of people attending workshops, training and tours related to integrated pest management. Number of certified and re-certified pesticide applicators.

Year	Actual
2016	1883

Output #4

Output Measure

- Number of new pest reports for counties and the state.

Year	Actual
2016	10

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Range: Increase in number of producers and small acreage landowners who are aware of the identification of pest infestations, and quickly identify new problems so they can make timely management decisions. Increase the number of producers/ranch managers who implement range monitoring activities which lead to improvement in resource management strategies.
2	Weed and Pest Control: Increase in the number of applicators who are certified and employ safety precautions and risk management strategies while using pesticides in the most environmentally and economically effective manner. Increased number of county agents trained to identify pests, limiting number of samples that have to be sent to Schutter Diagnostic Lab. Timely follow up by agents or SDL staff and specialists to identify pests, disease and plants and follow-up with appropriate recommendations.
3	Develop, enhance and distribute pest management programs
4	Increase knowledge and management of pests, diseases and plants affecting producers
5	Develop seasonal management programs and applied pest and disease management research

Outcome #1

1. Outcome Measures

Range: Increase in number of producers and small acreage landowners who are aware of the identification of pest infestations, and quickly identify new problems so they can make timely management decisions. Increase the number of producers/ranch managers who implement range monitoring activities which lead to improvement in resource management strategies.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	910

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Invasive plants have established on portions of range and wild lands throughout Montana. These plants result in environmental and economic impacts that can be mediated by knowledge about their biology and ecology and implementation of sound integrated management methods. Many of these plants are listed as state and county noxious weeds, suggesting they have been deemed problematic by stakeholders, including the state department of agriculture, county weed districts, private producers and public land managers. Equipping stakeholders with information will result in improved management and protection of range and wild land resources.

What has been done
One specialist conducted 20 presentations statewide, held a 3-day weed management workshop, appeared on Montana Ag Live 4 times, distributed 12 monthly weed posts and published 4 Extension publications, 5 peer-reviewed journal articles and 1 article in the COA and Extension Research Report. Two specialists completed an assessment of the economic impact of noxious weeds on private grazing lands in Montana. An agent and specialist conducted a study on controlling narrowleaf hawksbeard (Crepis tectorum) on Conservation Reserve Program land. Extension worked with the Montana Noxious Weed Education Coordinator to launch an on-line training module for real estate agents. Extension developed a Montana noxious weed key for the EDDMapS West smartphone app.

Results
Stakeholders have an improved understanding of the biology, ecology and management of invasive plants on Montana range and wild lands. For the five program evaluations conducted in 2016, level of awareness of the topic before the program averaged 2.8 (1=poor, 5=excellent);

after the program, level of awareness averaged 4.2. For the online realtor course, before taking the course 45% of the participants have informed/directed clients to resources about noxious weeds on properties; after completing the course 85% of the participants do/will inform/direct clients (sellers/buyers) to resources about noxious weeds on properties. For the Montana noxious weed key smartphone app, the iPhone app has been downloaded 1,433 times and the Android app 603 times. The key is being adapted by Bugwood for use in an app for Iowa Stormwater Education Partnership. Stakeholders are beginning to apply more informed management of invasive plants on the range and wild lands of Montana. The realtor course potentially impacts $30 million in real estate sales and 250,000 acres of property in 2016 (based on estimates of participants who were interviewed via phone following completion of the course).

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Diseases and Nematodes Affecting Plants
213	Weeds Affecting Plants
214	Vertebrates, Mollusks, and Other Pests Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals
601	Economics of Agricultural Production and Farm Management
603	Market Economics
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins
721	Insects and Other Pests Affecting Humans
903	Communication, Education, and Information Delivery

Outcome #2

1. Outcome Measures

Weed and Pest Control: Increase in the number of applicators who are certified and employ safety precautions and risk management strategies while using pesticides in the most environmentally and economically effective manner. Increased number of county agents trained to identify pests, limiting number of samples that have to be sent to Schutter Diagnostic Lab. Timely follow up by agents or SDL staff and specialists to identify pests, disease and plants and follow-up with appropriate recommendations.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	1883

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The MSU Pesticide Education Program provides training and program licensing to approximately 6,100 private applicators across Montana. According to a Memorandum of Understanding between the Montana Department of Agriculture and MSU Extension, MSU Extension is responsible for managing the private applicator program. Without this license, producers could lose the ability to manage pest outbreaks thus causing significant revenue losses. The program also trains applicators in non-target toxicity, security of pesticides, and the safe and effective use of pesticides to minimize negative environmental impacts and poisonings across the state.

What has been done
Delivered 62 presentations statewide in seven core subject areas. Focused on educating applicators on how to calibrate sprayers as failure to do so often causes non-target toxicity while costing money. In addition, Extension faculty in 56 county/reservation offices received calibration kits and calibration training which will decrease pesticide waste, decrease non-target impacts from using chemicals and reduce ineffective applications due to rates far lower than ideal for managing pests. Also focused on helping applicators understand the potential risk of unsecured pesticides to children, as well as the intended and unintended misuse that might occur through theft.

Results
Evaluations were collected at 10 pesticide education presentations on security (n=200). There was a 50% increase in the number who said they would begin securing pesticides. At 13 classes on calibration, participants'(n=356) ability to properly calibrate spray equipment increased from 48.5% to 91%.The average overall quality of all the PEP classes was 4.4/5. Written surveys were received back from 656 respondents. 92% consider the PAT program to be valuable or very valuable. 26% indicated they would lose their license as a result of decreased MSU Extension PAT productivity if funding was cut. 70% of respondents indicated the loss of their pesticide license would cause moderate to significant economic losses. Reported economic losses from the hypothetical loss of license if there was one pest outbreak were: $0-$1k = 18%, $1k-$5k = 27%, $5k -10K = 22%, $10k - $50k = 23%, $50K+ = 10%. According to this data, if 26% of current applicators lost their license, 786 producers would lose at least $5,000 from outbreak. This represents $3,930,000/outbreak in losses that could result if the MSU Extension PEP program was discontinued.

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Diseases and Nematodes Affecting Plants
213	Weeds Affecting Plants
214	Vertebrates, Mollusks, and Other Pests Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals
601	Economics of Agricultural Production and Farm Management
603	Market Economics
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins
721	Insects and Other Pests Affecting Humans
903	Communication, Education, and Information Delivery

Outcome #3

1. Outcome Measures

Develop, enhance and distribute pest management programs

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	34

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Montana has a $50 million quality seed potato industry and protecting these farms from disease is critical to the industry. Home gardens have long been a concern for disease spread. From 2013-2015, the MSU Potato Lab performed a survey of seed potatoes purchased from sources outside

of Montana. These included mail-order and local retail-sourced potatoes. The survey found that >50% of seed lots contained very high levels of virus. In 2014, two lots were found with bacterial ringrot which is a zero tolerance pathogen for Montana Seed Potato producers. Historically, it was difficult to obtain a variety of Montana grown seed potatoes.

What has been done
A garden seed potato distribution network has been established where orders are placed on a website and the potatoes are delivered to county Extension offices. The logistics of the distribution network, pricing, and recruitment of MT seed potato growers to supply high quality, disease-free Montana potatoes for the program takes place at an annual meeting of the Montana Potato Improvement Association. MSU Extension statewide helps distribute the product and also educates gardeners about the risk of using non-certified potatoes.

Results
Certified disease-free, Montana seed potatoes were delivered to 34 counties and reservations. In addition, more than 15 tons of Montana's certified seed potatoes were distributed to 46 garden centers, nurseries and market farms, as well as three schools. Counties that cooperate with the distribution network have developed relationships with local businesses and farms they may not have otherwise connected with. Some county offices purchase potatoes and sell them directly from their office which increases traffic and introduces Extension to a more broad audience.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals
601	Economics of Agricultural Production and Farm Management
603	Market Economics
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins
903	Communication, Education, and Information Delivery

Outcome #4

1. Outcome Measures

Increase knowledge and management of pests, diseases and plants affecting producers

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	3514

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
MSU COA, MAES and MSU Extension provide plant pest identification through the Schutter Diagnostic Laboratory (SDL). SDL provides the citizens of Montana with the highest quality diagnostic laboratory support. The SDL safeguards Montana agriculture, landscapes and public spaces from plant pests by offering identification services, management advice, and education. Recommendations from SDL are based on IPM principles, which is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health and environment risks.

What has been done
In 2016, the SDL conducted a total of 3,514 plant disease, insect and plant identification diagnoses. The white satin moth, Leucoma salicis, was diagnosed for the first time in Gallatin, Silver Bow, Cascade and Big Horn Counties. The white satin moth is a serious defoliator of willows, aspens, cottonwoods, and poplars. Another first report was the weed, cutleaf teasel (Dipsacus laciniatus), which is listed as a noxious weed in Colorado, Iowa, Missouri and Oregon.

Results
The estimated savings reported by SDL clients due to implementing SDL recommendations (n=73) was $4,795,103. Survey and testimonials from SDL include: 96% of clients likely to recommend; 90% of respondents said SDL influenced their pest management decision; 93% excellent or good rating for timeliness of response rate; 97% excellent or good rating for ease of submitting a sample.
"Educating producers about the ramifications of tearing out winter wheat and seeding a spring cereal grain helped save 40 bushel per acre in winter wheat yield. If 10 producers would have destroyed their winter wheat and seeded spring cereals, their yields would have been zero, a loss of $256,000."
"I appreciate having the SDL. Knowing the problem is important before taking action. Some people just get pesticide and start spraying. SDL is an important part of MSU Extension."
"I have a number of trees located in the vicinity of the affected tree that could have been impacted. I saved the huge expense of replacing them. I was better informed about fireblight and the management of it. The lab was terrific about providing immediate and thorough information about the situation."

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Diseases and Nematodes Affecting Plants
213	Weeds Affecting Plants
214	Vertebrates, Mollusks, and Other Pests Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals
601	Economics of Agricultural Production and Farm Management
603	Market Economics
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins
721	Insects and Other Pests Affecting Humans
903	Communication, Education, and Information Delivery

Outcome #5

1. Outcome Measures

Develop seasonal management programs and applied pest and disease management research

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Field crops are an important foundation for the Montana agricultural industry, totaling $2 billion annually. Field crops not only support world markets, but livestock forage as well. Plant and pest disease management and research are critical to Montana's foundational economy and

associated industries. Providing timely, practical and affordable disease and pest management and treatment research is a primary commitment of MSU integrated pest management programs.

What has been done
Foliar fungicide was tested and used for disease control, following a great deal of interest expressed by farmers, county agents, and industry personnel about the effectiveness of foliar fungicides and the best timing of application to control wheat diseases including stripe rust. The ecology and epidemiology of wheat viruses were investigated and additional other wheat viruses present in the United States were researched. Experiments were completed to investigate the susceptibility of wheat varieties for Montana growers faced with Wheat streak mosaic virus strains from different states.

Results
A research project was conducted for the third year with farmer cooperators testing the application of fungicide in the absence of disease. Data is being compiled. The third and final year of field trials investigating the effect of planting date, variety, and nitrogen application timing were completed in Bozeman, which helped support a master's thesis titled: "The effect of agronomic practices on disease management in Montana cropping systems." A severe epidemic of Wheat steak mosaic virus in the north central portion of Montana and while mold of lentil north eastern Montana occurred in 2016. 29 AgAlerts were published, 29 extension presentations to 2066 participants and three appearances on Montana PBS were distributed. Many small grain cultivars were examined for yield potential and pest and disease resistance. Winter and spring wheat nurseries were inoculated with stripe rust to understand rate of infection and associated protein percentages. The Orange Blossom Wheat Midge was managed by observation nurseries at two locations in order to evaluate new spring wheat lines with midge resistance. Monitoring efforts were carried out at eight locations in the Flathead Valley for both the midge and its parasitoid.

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Diseases and Nematodes Affecting Plants
213	Weeds Affecting Plants
214	Vertebrates, Mollusks, and Other Pests Affecting Plants
215	Biological Control of Pests Affecting Plants
216	Integrated Pest Management Systems
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals
601	Economics of Agricultural Production and Farm Management
603	Market Economics
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
712	Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins
721	Insects and Other Pests Affecting Humans
903	Communication, Education, and Information Delivery

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

Brief Explanation

A warming climate, new and emerging pests and diseases due to unpredictable weather patterns, increasingly threatened natural resources, and global may have affected program outcomes. Federal IPM funding has remained relatively flat for the last 20 years, leaving state funds and commodity grower groups to meet a decline in funding. Due to an intensified and increased global trade market, Montana and the United States are facing an increase of invasive non-native pests. Changes in federal policy and the continued growth of herbicide resistance may also have affected programs.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

An increase in public concern about food safety, quality, cost, biodiversity, and the sustainability of natural resources such as soil, air, and water quality is pushing scientists to rely less on pesticides and look for more environmentally-friendly options. In 2016, researchers again explored new and improved methods to identify and control insects, weeds, and diseases challenging Montana farmers and studied biological controls as low impact pest control options to promote sustainable practices. Producers and researchers continued to evaluate these new integrated pest management (IPM) methodologies so that Montana rowers can maintain a competitive position in U.S. and world markets. In Montana and throughout the U.S., maintaining profitable agricultural enterprises while sustaining ecological systems has become a difficult balancing act that often results in changes in agricultural practices and environmental policies. COA/MAES and Extension professionals continued quality in-depth training programs for continued integrated pest management education to discover, evaluate or change new IPM priorities and projects. Additional outcomes included new products registered, an increased passing rate percentage for pesticide application licenses and a number of new broad-ranging stewardship practices were implemented. The importance of integrated pest management remained a consistently critical field as invasive plant and pest species continue to threaten Montana's agricultural economy as well as the global safety of the state's food exports.
Research evaluations included:
One specialist conducted 20 presentations statewide, held a 3-day weed management workshop, appeared on Montana Ag Live 4 times, distributed 12 monthly weed posts and published 4 Extension publications, 5 peer-reviewed journal articles and 1 article in the COA and Extension Research Report. Two specialists completed an assessment of the economic impact of noxious weeds on private grazing lands in Montana. An agent and specialist conducted a study on controlling narrowleaf hawksbeard (Crepis tectorum) on Conservation Reserve Program land. Extension worked with the Montana Noxious Weed Education Coordinator to launch an on-line training module for real estate agents.
Stakeholders have an improved understanding of the biology, ecology and management of

invasive plants on Montana range and wild lands. For the five program evaluations conducted in 2016, level of awareness of the topic before the program averaged 2.8 (1=poor, 5=excellent); after the program, level of awareness averaged 4.2. For the online realtor course, before taking the course 45% of the participants have informed/directed clients to resources about noxious weeds.
Evaluations were collected at 10 pesticide education presentations on security (n=200). There was a 50% increase in the number who said they would begin securing pesticides. At 13 classes on calibration, participants'(n=356) ability to properly calibrate spray equipment increased from 48.5% to 91%.The average overall quality of all the PEP classes was 4.4/5. Written surveys were received back from 656 respondents. 92% consider the PAT program to be valuable or very valuable. 26% indicated they would lose their license as a result of decreased MSU Extension PAT productivity if funding was cut. 70% of respondents indicated the loss of their pesticide license would cause moderate to significant economic losses. Reported economic losses from the hypothetical loss of license if there was one pest outbreak were: $0-$1k = 18%, $1k-$5k = 27%, $5k -10K = 22%, $10k - $50k = 23%, $50K+ = 10%. According to this data, if 26% of current applicators lost their license, 786 producers would lose at least $5,000 from outbreak. This represents $3,930,000/outbreak in losses that could result if the MSU Extension PEP program was discontinued.
Delivered 62 presentations statewide in seven core subject areas. Focused on educating applicators on how to calibrate sprayers as failure to do so often causes non-target toxicity while costing money. In addition, Extension faculty in 56 county/reservation offices received calibration kits and calibration training which will decrease pesticide waste, decrease non-target impacts from using chemicals and reduce ineffective applications due to rates far lower than ideal for managing pests. Also focused on helping applicators understand the potential risk of unsecured pesticides to children, as well as the intended and unintended misuse that might occur through theft.
Foliar fungicide was tested and used for disease control, following a great deal of interest expressed by farmers, county agents, and industry personnel about the effectiveness of foliar fungicides and the best timing of application to control wheat diseases including stripe rust. The ecology and epidemiology of wheat viruses were investigated and additional other wheat viruses present in the United States were researched. Experiments were completed to investigate the susceptibility of wheat varieties for Montana growers faced with Wheat streak mosaic virus strains from different states.

Key Items of Evaluation

Perhaps the bulk of MSU research and Extension programming has was focused within Integrated Pest Management for Montana in 2016. Montana, like other states in the Northern Rockies and Great Northern Plains, is facing emerging pests and diseases due to a changing climate and external economic and environmental factors.
Evaluation results highlighted this year include:
Certified disease-free, Montana seed potatoes were delivered to 34 counties and reservations. In addition, more than 15 tons of Montana's certified seed potatoes were distributed to 46 garden centers, nurseries and market farms, as well as three schools.
Increase in the number of applicators who are certified and employ safety precautions and risk management strategies while using pesticides in the most environmentally and economically effective manner. Increased number of county agents trained to identify pests, limiting number of samples that have to be sent to Schutter Diagnostic Lab. Timely follow up by agents or SDL staff and specialists to identify pests, disease and plants and follow-up with appropriate recommendations in weed and pest control.

In 2016, the SDL conducted a total of 3,514 plant disease, insect and plant identification diagnoses. The white satin moth, Leucoma salicis, was diagnosed for the first time in Gallatin, Silver Bow, Cascade and Big Horn Counties. The white satin moth is a serious defoliator of willows, aspens, cottonwoods, and poplars. Another first report was the weed, cutleaf teasel (Dipsacus laciniatus), which is listed as a noxious weed in Colorado, Iowa, Missouri and Oregon.he estimated savings reported by SDL clients due to implementing SDL recommendations (n=73) was $4,795,103. Survey and testimonials from SDL include: 96% of clients likely to recommend; 90% of respondents said SDL influenced their pest management decision; 93% excellent or good rating for timeliness of response rate; 97% excellent or good rating for ease of submitting a sample.

A research project was conducted for the third year with farmer cooperators testing the application of fungicide in the absence of disease. Data is being compiled. The third and final year of field trials investigating the effect of planting date, variety, and nitrogen application timing were completed in Bozeman, which helped support a master's thesis titled: "The effect of agronomic practices on disease management in Montana cropping systems.
A severe epidemic of Wheat steak mosaic virus in the north central portion of Montana and while mold of lentil north eastern Montana occurred in 2016. 29 AgAlerts were published, 29 extension presentations to 2066 participants and three appearances on Montana PBS were distributed. Many small grain cultivars were examined for yield potential and pest and disease resistance.
Winter and spring wheat nurseries were inoculated with stripe rust to understand rate of infection and associated protein percentages. The Orange Blossom Wheat Midge was managed by observation nurseries at two locations in order to evaluate new spring wheat lines with midge resistance.
Foliar fungicide was tested and used for disease control, following a great deal of interest expressed by farmers, county agents, and industry personnel about the effectiveness of foliar fungicides and the best timing of application to control wheat diseases including stripe rust.
A garden seed potato distribution network has been established where orders are placed on a website and the potatoes are delivered to county Extension offices. The logistics of the distribution network, pricing, and recruitment of MT seed potato growers to supply high quality, disease-free Montana potatoes for the program takes place at an annual meeting of the Montana Potato Improvement Association.
Delivered 62 presentations statewide in seven core subject areas. Focused on educating applicators on how to calibrate sprayers as failure to do so often causes non-target toxicity while costing money.
Stakeholders are beginning to apply more informed management of invasive plants on the range and wild lands of Montana.
Increase in the number of applicators who are certified and employ safety precautions and risk management strategies while using pesticides in the most environmentally and economically effective manner. Increased number of county agents trained to identify pests, limiting number of samples that have to be sent to Schutter Diagnostic Lab.
Timely follow up by agents or SDL staff and specialists to identify pests, disease and plants and follow-up with appropriate recommendations.

V(A). Planned Program (Summary)

Program # 5

1. Name of the Planned Program

Energy 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
102	Soil, Plant, Water, Nutrient Relationships	5%		10%	
104	Protect Soil from Harmful Effects of Natural Elements	5%		10%	
111	Conservation and Efficient Use of Water	0%		5%	
112	Watershed Protection and Management	5%		3%	
122	Management and Control of Forest and Range Fires	5%		8%	
123	Management and Sustainability of Forest Resources	10%		4%	
124	Urban Forestry	5%		2%	
131	Alternative Uses of Land	5%		5%	
132	Weather and Climate	5%		7%	
135	Aquatic and Terrestrial Wildlife	5%		5%	
136	Conservation of Biological Diversity	5%		14%	
141	Air Resource Protection and Management	0%		9%	
402	Engineering Systems and Equipment	5%		4%	
605	Natural Resource and Environmental Economics	5%		8%	
610	Domestic Policy Analysis	0%		3%	
903	Communication, Education, and Information Delivery	35%		3%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	4.5	0.0	22.9	0.0
Actual Paid	2.5	0.0	67.2	0.0

Actual Volunteer	0.7	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**
39333	0	474454	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	3800977	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
77307	0	2046045	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

COA, MAES and Extension worked one-on-one and in groups with landowners and consumers to identify and address individual and industry struggles and solutions. They answered specific questions through workshops, phone calls, email and personal consultations, addressing topics such as forest and rangeland stewardship and water quality.
COA, MAES and Extension partnered with local and state associations and organizations that are concerned about natural resource issues. In particular, they engaged with leaders concerned about natural resources to find ways to provide meaningful education and research while collaborating to solve problems and create strategies for future growth and development. Agents and specialists offered classes, workshops, group discussions, demonstrations, online resources and field tours/trials. Agents, specialists and volunteers disseminated knowledge via community events and meetings, websites and social media. MSU Extension utilized PSA's, newsletters, MONTGuides, television, eXtension, listservs, social media, and other sources to share information.

In the research vein, COA/MAES continued to produce meaningful scholarly research that expand the global knowledge of important research foci in Energy and Natural Resources mainly within; water protection, maintenance and advancement of ecological systems, sustainable rangeland recovery and advancements, microbial interactions in thermal temperatures, and the development and use of multi-scale geospatial monitoring systems for vegetation and land-use dynamics. The creation and dissemination of scholarly research in these veins included, but was not limited to:

- Microbial interactions in high-temperature chemotropic communities and microbiological processes (Yellowstone National Park)
- Montana watershed abudance, sustainability and protection
- Contributed to state managment of federal agencies with peer-reviewed scholarshly reserach on the effective managment of rangeland ecosystems, livestock and crop production and the increasing urban/wildlife corridor interface in agriculture and western lands
- Development of multi-scale geospatial monitoring systems for vegetation and land-use dynamics
- Biobased fibruous materials for cleaner technologies for a sustainable and environmentally friendly responsible textile industry
- Ecological landscape design in Brownfield regeneration

• Embracing natural patterns in discontinuity to provide a more scalable and applicable understanding of Montana streams and watersheds.
• Restoration of ecological systems in the context of aboveground-belowground linkages
• Remote sensing for Montana land resources
• Rangeland ecology and advancing the ecology in the sustainable management of Rangeland systems
• Biological roots and physical constraints to macroscopic patterns of nitrogen cycling on land

2. Brief description of the target audience

• Private forest and rangeland owners and public land managers
• Farmers/Ranchers/Ag Producers
• Small acreage landowners
• Community leaders
• Watershed and waterway users
• Professional loggers/foresters/rangeland managers
• Environmental scientists
• State economists

3. How was eXtension used?

eXtension was used to research materials to prepare presentations. eXtension was also used to share information through fact sheets and answer Ask an Expert questions via the Rangeland Stewardship and Health Community of Practice (COP). Questions for Ask an Expert are also used to assess clientele needs and help guide programming.

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	10686	2737	1814	3600

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

Patent Applications Submitted

Year:	2016
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	22	150	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2016	172

Output #2

Output Measure

- Number of meetings/workshops/clinics/private consultations aimed at forest and rangeland stewardship. Number of landowners and managers who create and implement forest stewardship plans.

Year	Actual
2016	500

Output #3

Output Measure

- Number of people attending Well Educated programs, who track water quality, regularly test their wells and receive information on how to help protect ground water resources. Number of people attending workshops and seminars to learn about watersheds and environmentally sustainable best practices.

Year	Actual
2016	760

Output #4

Output Measure

- Number of consumers, landowners and industry professionals utilizing energy efficiency resources created and/or consolidated by MSU Extension programs.

Year	Actual
2016	302

Output #5

Output Measure

- Number of workshops and resources provided to assist landowners with leasing of mineral and water rights and other legal issues related to development. Number of collaborations with industry, agriculture and community leaders in eastern Montana.

Year	Actual
2016	200

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Increased number of private forest owners who create and implement forest stewardship plans that allow them to continue to provide economic, environmental and social benefits to Montanans. Increased number of people who gain knowledge about forestry management and sustainability issues and contribute to forest health.
2	Increased number of homeowners regularly testing wells and managing them for safe consumption and environmental soundness. Increased number of Montanans who utilize online Extension and other resources related to watershed protection, drinking water safety and other water quality topics.
3	Energy Efficiency and Alternatives: Increased number of consumers accessing and utilizing Extension resources and participating in training to improve efficiency, reduce environmental impacts and lower costs.
4	Natural Resource Development: Increased number of collaborations with partners in eastern Montana to explore benefits and challenges as a result of the Bakken Oil Field and related issues. Increase in the number of landowners who are educated and make sound decisions about water and mineral rights.
5	Bio-energy research: Continued examination of the potential for greater utilization of hazardous forest fuels as a source of alternative carbon neutral liquid fuel production.
6	Increased knowledge and use of best management practices for successfully integrating livestock grazing with fish and wildlife resources.
7	Increased knowledge and practice of sustainable livestock grazing practices on forests, rangeland and pastures.
8	Increased awareness about how communities can best address challenges and opportunities related to oil and gas development.
9	Advance the Ecology in the Sustainable Management of Rangeland Systems

Outcome #1

1. Outcome Measures

Increased number of private forest owners who create and implement forest stewardship plans that allow them to continue to provide economic, environmental and social benefits to Montanans. Increased number of people who gain knowledge about forestry management and sustainability issues and contribute to forest health.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	683

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Montana has 25 million acres of forest, of which 4.4 million are owned by over 52,000 private individuals (who own 5+ acres). Historically these family owned forests have supplied 30% of annual Montana timber harvest, today it's over 50%. Loggers can become Accredited Logging Professionals if they pass stewardship classes. Family forests also provide open space, clean water, wildlife habitat, and the recreational opportunities for which Montana is famous. In years of severe wildfire, these lands, when well managed, have provided an important wildfire control buffer between wildlands and surrounding communities. The Montana Forest Stewardship Steering Committee advises MSU Extension Forestry in how to best meet the needs of these landowners.

What has been done
Extension Forestry provides forest landowner education programs ranging from core Forest Stewardship Planning Workshops to topic specific workshops like Windbreaks/Living Snowfences, Alternative Forest Management Practices, Wildfire Hazard Reduction, and Tree Pruning and Care. In addition, MSU Extension Forestry teaches the Project Learning Tree (PLT) environmental education program to teachers, other educators, parents and community leaders who work with youth from preschool through grade 12. In 2016, 80 educators participated, 95% will use PLT in their classes, reaching over 1500 students. Extension Forestry also provides outreach through various tools including a calendar, news releases, listservs, twitter, brochures and publications.

Results
Forest Stewardship Workshop for Loggers: 100% learned communication that would help them work with families, 89% learned ecological information they would use in their day-to-day

activities. One commented, "Although I usually make a grand a day, this was money well spent and not earned."
Forest Stewardship Workshops (4): 90% of participating owners submitted a stewardship plan. These owners managed 19,000 acres. Over 60% planned to apply for cost-share funds to thin and reduce fire hazards. Management practice changes will improve 11,450 acres of wildlife habitat, 4,151 acres for water quality, 9,994 acres for forest health, and 8,545 acres for wildfire hazard reduction and resilience. One participant followed up, "We received grants from the Bitterroot RC&D (fire hazard reduction/logging) & DNRC (weed control). Our logging project is nearly complete..., seeding done...and we are going into our third round of weed control. We identified Missoula's first reported case of a different knapweed on our property w/plot inventory and plant identification skills learned from class...We feel the class has paid us back in huge dividends."

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
104	Protect Soil from Harmful Effects of Natural Elements
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
122	Management and Control of Forest and Range Fires
123	Management and Sustainability of Forest Resources
124	Urban Forestry
131	Alternative Uses of Land
132	Weather and Climate
135	Aquatic and Terrestrial Wildlife
136	Conservation of Biological Diversity
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

Outcome #2

1. Outcome Measures

Increased number of homeowners regularly testing wells and managing them for safe consumption and environmental soundness. Increased number of Montanans who utilize online Extension and other resources related to watershed protection, drinking water safety and other water quality topics.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	1194

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Montana has 60,000 miles of perennial streams which provide irrigation, drinking water and recreation. Approximately 45 percent of those streams are listed as impaired. Non-point sources of pollution, which everyone plays a role in, cause most of the impairment. To improve management, the general public must understand that their actions have an impact and make decisions that mitigate damage. There is no government oversight of water quality for private drinking water wells so it is the homeowner's responsibility to test and understand their water quality.

What has been done
MSU Extension Water Quality (MSUEWQ) works with county partners and agencies to engage citizens in data collection to understand surface and groundwater issues, and also provides leadership of the Water Committee under the statewide Watershed Coordination Council. MSUEWQ offered seven classes: ArcMap Desktop Training, ArcOnline, Water Monitoring, Montana Watersheds and Water Quality Overview, Watershed 101 and Discharge Measurement, and Achieving Riparian Assessment through Stream Teams. The Big Sky Watershed Corp program placed 20 recent college graduates with local conservation groups across Montana. Through a variety of conservation groups, MSUEWQ provided data collection-storage-visualization assistance and assistance for visualizing watershed areas in maps.

Results
Participants in the Big Sky Watershed Corp program rated the overall quality of workshops with a mean score of 4.6/5. All 20 indicated that they learned practical information that would help them accomplish their host site goals. Recent GIS and water monitoring efforts are beginning to combine data and photo visualization with online interactive maps. Examples available on the MSUEWQ website include the Musselshell Salinity Project, the Madison Stream Team project and an interactive map of the Deep Creek project near Townsend, MT. Participants in the Well Educated Program indicated that program materials were informative and that following the program, they were able to identify and address issues associated with water quality in their private water supplies, including treating bacteria contamination, replacing problematic well caps and addressing threats to water quality in proximity to well heads. Data from the program also resulted in successful research grant funding to address water quality issues in Montana. On the Flathead Reservation, 434 participants took part in "River Honoring 2016". Students did hands-on riparian reconstruction to stabilize banks in a milk carton material that mimics soil.

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
132	Weather and Climate
136	Conservation of Biological Diversity
903	Communication, Education, and Information Delivery

Outcome #3

1. Outcome Measures

Energy Efficiency and Alternatives: Increased number of consumers accessing and utilizing Extension resources and participating in training to improve efficiency, reduce environmental impacts and lower costs.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	302

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Consumers are interested in reducing consumption, using more efficient energy sources and learning the latest technologies and solutions for being good stewards of limited resources. Finding reliable, science-based information can be a challenge. The MSU Extension Weatherization Center offers resources, training and certifications for contractors, businesses and individuals. The Center works closely with Montana's Human Resource Development Councils and Tribal associates to utilize safe, efficient, cutting edge techniques to address the health, safety and energy efficiency issues present in low-income housing.

What has been done
MSU Extension's Montana Weatherization Training Center (WTC) provided training and technical assistance to the Montana Weatherization workforce in collaboration with the Montana Department of Health and Human Services. The WTC offered 44 classes with 304 participants. These covered topics such as: Basic Furnace Training; Weatherization 101; Crew Leader Management; Insulation Systems and Applications; Single Family Energy Auditor; EPA Renovation, Repair and Painting Refresher; and Mobile Home Weatherization. In addition, the WTC provided technical assistance via email, phone and in meetings, wrote technical manuals for the state, aided agencies with field assessments and maintained a website with videos that have reached more than 2 million individuals (wxtvonline.org).

Results
The WTC certified 302 individuals in various classes. More than 1,000 low-income homes were worked on by individuals trained through the WTC. Quality Control Inspections (QCI) were performed on a random selection of homes that were worked on by grant participants trained by WTC. These homes showed significant improvements in energy efficiency which lowers the financial burden of energy bills for the low-income individuals living within them. Ninety-one percent passed the rigorous inspections indicating they met or exceeded DOE standards for energy-efficient retrofit. Nationally, homes that are retrofitted save an average of $283 annually on energy costs and approximately $14,000 in health and household, non-energy benefits per home.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
141	Air Resource Protection and Management
402	Engineering Systems and Equipment
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

Outcome #4

1. Outcome Measures

Natural Resource Development: Increased number of collaborations with partners in eastern Montana to explore benefits and challenges as a result of the Bakken Oil Field and related issues. Increase in the number of landowners who are educated and make sound decisions about water and mineral rights.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Addressing the challenges and opportunities associated with oil and gas development has

become an emerging initiative for Extension faculty, with increasing demands for facilitated community engagement, educational outreach and coordinated research. No longer solely a technical or environmental issue, communities that host onshore oil and gas development require that Extension faculty address many interdisciplinary topics related to social and economic issues. Extension is seeking to learn more about best practices and resources needed to address impacts from hydraulic fracturing, regional shale development planning, and general health and well-being associated with oil and gas development in communities.

What has been done
Now in the third year with funding from a USDA NIFA grant, a four-state team (Penn State, Cornell, University of Wyoming, Montana State) has established a national Extension communications strategy (called the National Extension Oil and Gas Communities Network) to share information and resources related to oil and gas educational outreach and research, conducted a national inventory of Extension activities and resources related to oil and gas outreach, and coordinated multiple community meetings and workshops for local citizens to learn about and plan for oil and gas development impacts.

Results
Evaluations and post workshop interviews have revealed a positive impact from the Extension activities. Participants report they have access to new networks and resources and are better prepared as a result of the Extension program. Program coordinators are now organizing a series of national 'summits' to convene interested Extension educators and practitioners to further strengthen existing networks to continue to work together to identify resources and optimal ways to engage constituents.

4. Associated Knowledge Areas

KA Code	Knowledge Area
104	Protect Soil from Harmful Effects of Natural Elements
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
131	Alternative Uses of Land
141	Air Resource Protection and Management
903	Communication, Education, and Information Delivery

Outcome #5

1. Outcome Measures

Bio-energy research: Continued examination of the potential for greater utilization of hazardous forest fuels as a source of alternative carbon neutral liquid fuel production.

Not Reporting on this Outcome Measure

Outcome #6

1. Outcome Measures

Increased knowledge and use of best management practices for successfully integrating livestock grazing with fish and wildlife resources.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Increased knowledge and use of best management practices for successfully integrating livestock grazing with fish and wildlife resources is critical to Montana landowners and their sustainable rangeland resource management in Montana. The invasion of new and emerging pests and disease directly affects Montana livestock production systems and best management practices for the integration of the growing urban, wildlife and agricultural shared corridors between waterways, livestock production, natural ecosystems and wildlife populations.

What has been done
Research was completed on sustainable rangeland resource management in Montana in the invasion of conifer trees into foothill ranagelands that threatens the ecological sustainability of these lands, which also threatens the economic sustainability of rural communities and their water supply, wildlife habitat quality and livestock and forage production. Projects evaluated long-term integration of grazing livestock with watershed and wildlife resources by identifying long-term efficacy of prescribed burning to suppress conifer invasion into foothill range land. Research also focused on determining the role of habitat type and grazing on sage-grouse in Centennial Valley and habitat selection findings for grizzly bears improving management decisions.

Results
Nesting, brood survival and habitat success of sage grouse was identified in the Centennial Valley. The influence of cattle grazing on nest selection and grizzly bear use of forest successional stages were determined, resulting in final results from three projects that have been shared at 5 meetings and copies sent to management agencies. Workshops were held throughout Montana for beef cattle producers and county Extension agents, engaging participants to interpret forage analysis. 35 livestock producers were reached in person via Extension programming about extensive livestock production systems. 5 county agents were trained to use

ration balancing software and incorporate management strategies that integrate a sustainable balance between wildlife systems, watersheds and livestock production for an integrated, sustainable management approach.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
122	Management and Control of Forest and Range Fires
123	Management and Sustainability of Forest Resources
131	Alternative Uses of Land
135	Aquatic and Terrestrial Wildlife
903	Communication, Education, and Information Delivery

Outcome #7

1. Outcome Measures

Increased knowledge and practice of sustainable livestock grazing practices on forests, rangeland and pastures.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	3376

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Rangelands comprise 70 percent of Montana's 93 million acres, and rangelands provide much of what makes Montana a special place, including clean air and water, scenic open spaces, and abundant wildlife. Rangelands also support Montana's second largest industry - range-livestock agriculture. Range management issues include: livestock grazing conflicts with fish, wildlife, and recreation; invasive plants; increased future food and fiber demands; conversion of rangelands to cropland, ex-urbanization and urbanization; increasing pressure for range livestock producers to reduce greenhouse gas emissions and reduce use of water and energy; and land ownership transfer to amenity landowners and to less experienced livestock producers.

What has been done
During 2016, the Extension Rangeland Specialist and Forage Specialist taught 68 classes (i.e:

Rangeland Monitoring In Sage-Grouse Habitat, Options for Suppressing Cheatgrass, Grazing Management for Smaller Acres, Optimizing Hay Management, Forage Testing and Interpretation, Variety Selection and more) directly reaching 3,315 people. They also responded to individual requests for information from clientele, including from county/reservation Extension faculty and directly from ranchers and other landowners. They published two refereed journal articles and created two more MontGuides (fact Sheets) - Forage Analysis Interpretation and Collecting a Feed or Forage Sample for Analysis.

Results

Producers and landowners who used information from these classes improved the ecological, economic, and social sustainability of range livestock agriculture and improved the sustainability of rangeland ecosystem services, including clean air, clean water, outdoor recreation, fish and wildlife, carbon sequestration, open space and scenic beauty.

Nitrate Toxicity is an issue throughout Montana. High nitrate concentrations can lead to loss of forages, as well as negative health implications on livestock. Currently, only a qualitative test for nitrate concentration estimation is available through the MSU Extension service. Research is underway to provide producers and ranchers with a faster and better estimate of their nitrate levels to better manage nitrate toxicity.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
104	Protect Soil from Harmful Effects of Natural Elements
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
122	Management and Control of Forest and Range Fires
131	Alternative Uses of Land
132	Weather and Climate
135	Aquatic and Terrestrial Wildlife
136	Conservation of Biological Diversity
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

Outcome #8

1. Outcome Measures

Increased awareness about how communities can best address challenges and opportunities related to oil and gas development.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Addressing the challenges and opportunities associated with oil and gas development has become an emerging initiative for Extension faculty, with increasing demands for facilitated community engagement, educational outreach and coordinated research. No longer solely a technical or environmental issue, impacts in communities that host onshore oil and gas development require faculty to focus on a wide array of interdisciplinary topics related to social and economic issues. Extension is working to identify resources and best practices to address impacts from hydraulic fracturing, regional shale development, and general health and well-being associated with communities involved in oil and gas development.

What has been done
Now in the third year with funding from a USDA NIFA grant, the four-state team including Penn State, University of Wyoming, Cornell and Montana State University has:
- Established the National Extension Oil and Gas Communities Network to share information and resources related to oil and gas educational outreach and research
- Conducted a national inventory of Extension activities and resources related to oil and gas outreach
- Coordinated multiple community meetings and workshops for local citizens to learn about and plan for oil and gas development impacts.

Results
Evaluations and post workshop interviews have revealed a positive impact from the Extension activities. Participants report they have access to new networks and resources and are better prepared as a result of the Extension program. Program coordinators are now organizing a series of national 'summits' to convene interested Extension educators and practitioners to further strengthen existing networks to continue to work together to identify resources and optimal ways to engage constituents.

4. Associated Knowledge Areas

KA Code	Knowledge Area
131	Alternative Uses of Land
605	Natural Resource and Environmental Economics
610	Domestic Policy Analysis
903	Communication, Education, and Information Delivery

Outcome #9

1. Outcome Measures

Advance the Ecology in the Sustainable Management of Rangeland Systems

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Introduced species, woody plant expansion and climate change on rangelands threaten the ability of these lands to provide the ecological goods and services desired by society. An improved understanding of the relationships among range use, vegetation change, and ecological resilience and the potential interactions with future climatic regimes, is needed to ensure rangeland managers are equipped with with appropriate knowledge to best adapt to changing environmental conditions while still providing for the needs of society.

What has been done
MAES developed a research program to provide direction and support for rangeland management in dealing with current and future challenges including novel ecosystems associated with plant invasion and climate change. Research was based on the framework of ecological resilience seeking to understand rangeland ecology and management/disturbance response through the functional relationships of vegetation and soil as influenced by disturbance and climate variability, so that producers can maintain: meat protein, wildlife and wildlife habitat, clean air and water, biological diversity and recreational opportunities.

Results
Cheatgrass in the Great Basin has been identified as a competition for soil moisture. Cheatgrass research will continue to improve our understanding of the specific ecological conditions associated with cheatgrass invasion and to use this information to assist resource managers in developing management prescriptions appropriate for sites with reduced resistance or resilience to cheatgrass by quantifying the ecological site characteristics associated with locations showing evidence of cheatgrass invasions, quantifying disturbance of the history and intensity on sites showing evidence of invasion and evaluate the relationships among ecological site characteristics (soils, topography, climate, vegetation) and cheatgrass abundance.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
104	Protect Soil from Harmful Effects of Natural Elements
111	Conservation and Efficient Use of Water
122	Management and Control of Forest and Range Fires
123	Management and Sustainability of Forest Resources
131	Alternative Uses of Land
132	Weather and Climate
136	Conservation of Biological Diversity

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

Brief Explanation

Natural resources are greatly impacted by factors beyond human control, leaving those who depend on these resources challenged to develop flexible management plans that ensure resiliency, viability and profitability. Natural resources are also greatly impacted by humans in ways that aren't fully understood or that have become highly politicized. It is critical that unbiased, scientifically backed information is available through Extension and Research.
Accelerated growth in eastern Montana, followed by a sharp exodus of people, presents many challenges and opportunities which are and will continue to be affected by national and state government policies, funding for energy development issues, taxation policies and more. These rapid changes result in a great need for Extension and Research to provide science - based resources and facilitate community and leadership development to mitigate political and social impacts.
Other external factors include the inability for Extension to hire a new housing specialist.
The outcome target, "Bio-energy research: Continued examination of the potential for greater utilization of hazardous forest fuels as a source of alternative carbon neutral liquid fuel production" is far too specific to a former research Hatch project to accurately capture and report work being done in the Surface-Atmosphere Trace Gas and Energy Exchange in Forested and Agricultural Ecoysystems. It is not standard practice to report on a single Hatch project in the outcome section of this report.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

MSU COA/MAES and Extension continued to do meaningful work in energy and natural resources, particularly as related to forests, water, range and wildlife. Evaluations were mostly word of mouth and via survey. The broad impact is that Montana continues to be a vibrant, healthy state with significant revenue generated from natural resources and tourism, while continuing to support recreation and family activities. Exploratory research reflects the primary areas of Montana natural resources greatest needs in: water, range, forest ecology, wildfire, invasive species, sustainable integration of farm and ranch land in an increasing urban/wildlife corridor.
Energy and natural resource studies again became increasingly necessitated as major environmental changes accelerated. According to the Montana Department of Commerce, Montana has more potential for energy development from existing and untapped diversified sources than any other state in the nation. From coal deposits, oil, wind farms and geothermal energy potential, energy and natural resources have played a vital role in Montana's history and continue to be a priority for Extension and MAES. COA/MAES and Extension faculty continued to recruit competitive grant dollars and personnel to bolster current and forecasted research faculty lines, undergraduate and graduate students, programs and labs, as they relate indirectly and directly to the field of energy and natural resources. This program saw an increase of nine new Hatch projects, many of them interdisciplinary in nature - as they speak to research areas that rapid environmental change and natural resource and energy development has affected. The agricultural community in Montana wants to add value to Montana's high quality crop and livestock systems in ongoing adaptations in regard to the state's energy and natural resource base. Faculty in 2016 prioritized research exploring water, and researchers also explored climate in the wake of threatened natural resources.
COA/MAES and Extension professionals continued to make advancements in this critical research agenda and continued excelling in the discovery and communication of how natural and managed environments and their elements function in an era of global climate change. With more than 60,000 miles of perennial streams providing irrigation, drinking water and recreation, Extension and MAES partnered with communities and citizens to involve local people with data collection to better understand surface and groundwater issues. In addition, forests cover large areas and contribute to the economic base of the state while also serving as a critical natural resource for wildlife, recreation, tourism and cultural purposes. Extension and MAES provide unbiased, science-based research, education and outreach related to preserving and supporting the best use and management of these resources.

Key Items of Evaluation

- Forest Stewardship Workshop for Loggers: 100% learned communication that would help them work with families, 89% learned ecological information they would use in their day-to-day activities.
- Forest Stewardship Workshops: 90% of participating owners submitted stewardship plans. Over 60% planned to apply for cost-share funds to thin and reduce fire hazards. Management practice changes will improve 11,450 acres of wildlife habitat, 4,151 acres for water quality, 9,994 acres for forest health, and 8,545 acres for wildfire hazard reduction and resilience.
- Participants in the Big Sky Watershed Corp program rated the overall quality of workshops with a mean score of 4.6/5.
- GIS and water monitoring efforts are beginning to combine data and photo visualization with online interactive maps. Examples include the Musselshell Salinity Project, the Madison Stream Team project and an interactive map of the Deep Creek project near Townsend, MT.

- Participants in the Well Educated Program were able to identify and address issues associated with water quality in their private water supplies, including treating bacteria contamination, replacing problematic well caps and addressing threats to water quality in proximity to well heads. Data from the program also resulted in successful research grant funding to address water quality issues in Montana.
- The Weatherization Training Center certified 302 individuals in various classes. More than 1,000 low-income homes were worked on by individuals trained through the WTC. Ninety-one percent of randomly selected homes passed Quality Control Inspections, demonstrating significant improvements in energy efficiency which lowers the financial burden of energy bills for the low-income individuals living within them.
- Created the National Extension Oil and Gas Communities Network in partnership with Penn State, University of Wyoming and Cornell.
- Nesting, brood survival and habitat success of sage grouse in the Centennial Valley was investigated. The influence of cattle grazing on nest selection and grizzly bear use of forest successional stages were determined and final results from three projects were shared at five meetings.
- Thirty-five livestock producers were reached in person via Extension programming about extensive livestock production systems. Five additional county agents were trained to use ration balancing software and incorporate management strategies that integrate a sustainable balance between wildlife systems, watersheds and livestock production.
- Currently, only a qualitative test for nitrate concentration estimation is available through the MSU Extension service. Research is underway to provide producers and ranchers with a faster and better estimate of their nitrate levels to better manage nitrate toxicity.
- Cheatgrass research continues to improve our understanding of the specific ecological conditions associated with cheatgrass invasion and to use this information to assist resource managers in developing management prescriptions appropriate for sites with reduced resistance or resilience to cheatgrass.

V(A). Planned Program (Summary)

Program # 6

1. Name of the Planned Program

Youth and Family Development

☑ 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
307	Animal Management Systems	5%		0%	
602	Business Management, Finance, and Taxation	5%		0%	
801	Individual and Family Resource Management	25%		0%	
802	Human Development and Family Well-Being	25%		0%	
806	Youth Development	35%		0%	
903	Communication, Education, and Information Delivery	5%		0%	
	Total	100%		0%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	8.0	0.0	0.0	0.0
Actual Paid	12.1	0.0	0.0	0.0
Actual Volunteer	44.7	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**
385452	0	0	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	0	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
216874	0	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

• Collaborated with Native American reservations and 1994 land-grant institutions to provide culturally appropriate programming and related materials to Native American families.
• Conducted workshops and clinics that provide active learning and skill development
• Conducted meetings that focus on facilitation and leadership skills
• Developed curriculum and supporting teaching tools for volunteers to use
• Provided training for youth and adult volunteers
• Partnered with youth serving groups on state and local levels
• Provided/developed web-based education and information access
• Facilitated small support groups for caregivers
• Developed printed and online resources

2. Brief description of the target audience

• Youth aged 5-19
• Children ages 0-5
• Parents of youth involved in 4-H
• Adult and youth volunteer leaders
• Professionals involved with youth development
• School administrators and teachers
• Military families
• Rural and urban Montana families, landowners and business owners
• Caregivers
• Healthcare providers and services
• Reservation populations

3. How was eXtension used?

• Connecting with resources and specialists from other areas
• Youth leadership programming
• Peer-reviewed and innovative planning, program development and evaluation tools
• Leadership training
• Techniques for working with youth and adult volunteers
• 4-H curriculum

- Implementation of citizenship programs

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	13430	74827	20671	44792

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

Patent Applications Submitted

Year: 2016

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	37	0	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Youth competency development: Number of 4-H programs and activities to provide youth with training and support to foster the development of skills and abilities in citizenship, science and healthy living.

Year	Actual
2016	56

Output #2

Output Measure

- Youth life skill development: Number of 4-H Youth programs which provides activities and projects to help youth build specific life skills.

Year	Actual

2016	2838

Output #3

Output Measure

- Leadership/Volunteer Development: Number of classes, seminars and resources for youth and adults who volunteer in youth programs to help them become better, more effective leaders.

Year	Actual
2016	58

Output #4

Output Measure

- Military Family Partnerships: Number of positive interactions with military families through partnerships with other organizations and schools to access resources and provide support opportunities.
  Not reporting on this Output for this Annual Report

Output #5

Output Measure

- Parenting/Caregiving: Number of classes and support groups for parents and caregivers.

Year	Actual
2016	34

Output #6

Output Measure

- Personal Finances: Number of classes, training and resources that provide critical information related to personal finances and the Affordable Care Act (ACA).

Year	Actual
2016	70

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Youth competency development: Increased number of youth participating in 4-H projects and activities and demonstrating increased knowledge and ability in specific competency areas including but not limited to science, healthy living and citizenship.
2	Youth life skill development: Increased number of youth participating in 4-H activities and demonstrating increased knowledge and ability in specific life skill areas including but not limited to teamwork, communication skills and public speaking.
3	Leadership/Volunteer Development: Increased number of youth and adults who have received leadership training and demonstrate increased knowledge and ability as a result of the training.
4	Military Family Partnerships: Increased interaction with military families resulting in increased capacity of families to access resources and support.
5	Parenting/Caregiving: Increased number of parents and caregivers who access support and resources and increased knowledge and ability of participants as a result of those efforts.
6	Personal Finances: Increased number of participants in classes and training and increased knowledge and aptitude of those participants based on pre- and post- survey results. Increased number of ACA inquiries, referrals, resources developed and shared, workshops and enrollments.

Outcome #1

1. Outcome Measures

Youth competency development: Increased number of youth participating in 4-H projects and activities and demonstrating increased knowledge and ability in specific competency areas including but not limited to science, healthy living and citizenship.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	32376

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The Department of Commerce estimates that Science, Technology, Engineering and Math (STEM) occupations will grow 1.7 times faster than non-STEM jobs between 2008 and 2018. To meet these workforce needs, the United States will need approximately one million more STEM professionals than are projected to graduate over the next decade. Research has shown that 4-H members develop an increased interest in science three times higher than non-4-Hers.

What has been done
Montana youth participated in 32,376 projects related to (STEM) during 2016. These projects included robotics, bioscience, livestock, foods and nutrition, environmental education, plant sciences and engineering. NILE Ag in the Classroom reached 1800 fourth graders from Montana's largest community who learned about crops and livestock and how agriculture impacts their lives daily. Youth in Livestock projects learned about animal selection, training, care, record keeping, showmanship and marketing. The Western Heritage Project grew from five youth in Gallatin County in 2008 to 1396 youth from eight states in 2016.

Results
Youth increased their knowledge in finances including how to create a budget, understanding how credit scores work and the cost of insurance. In one community a local organization opened a savings account for all kindergarten students and Extension provided education to encourage the kids to continue saving. Through the Intermountain Livestock Judges training, 135 individuals were certified and went on to judge 823 county shows, 43 state shows and 36 regional shows. One alum noted, "After being in 4-H for 10 years, I still stay involved as much as I can by helping young members that are interested in livestock. It's exciting to see kids show their livestock for the first time. Seeing those proud smiles for all their hard work is worth every minute." Youth on the Flathead Reservation took tours of Ninepipes Reservoir, prehistoric Lake Missoula, Bozeman and

Butte taking video along the way. They created edited films and debuted them at a celebration with tribal elders. The project created an important generational connection through the use of technology and enhanced communication and technical skills.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems
602	Business Management, Finance, and Taxation
801	Individual and Family Resource Management
802	Human Development and Family Well-Being
806	Youth Development
903	Communication, Education, and Information Delivery

Outcome #2

1. Outcome Measures

Youth life skill development: Increased number of youth participating in 4-H activities and demonstrating increased knowledge and ability in specific life skill areas including but not limited to teamwork, communication skills and public speaking.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	18761

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Instability due to family situations and other challenges can lead young people to be at-risk. 4-H serves as a bridge between at-risk behavior and positive behavior. As our world continues to grow and change we need to prepare the youth of today for the future of tomorrow. 4-H grows and develops youth to be leaders with compassion, empathy and a vision: a vision to continue to make the world that we live in a better place. 4-H provides youth with critical life skills that will serve them their entire lives.

What has been done
Montana 4-H creates environments for positive youth development through experiential education, learning by doing projects, club meetings, community service projects, after-school

programs, school enrichment, camps, conferences, international programs and exchanges, other events and activities. During 2016, 18,761 youth participated in 4-H activities. Of these 8,825 were members of 4-H clubs. Over 17% were minorities compared to 11% of the state's overall population. 4-H directly contributes to the development of youth through programs in communication and public speaking, goal setting, professional etiquette, leadership and decision-making.

Results

Three counties piloting a communication skills evaluation reported increased ability from before starting 4-H to after, based on an ascending 1-7 scale (1 strongly disagree, 7 strongly agree).
* I know how to prepare a presentation: 3.76 to 6.04
* I can answer questions about my project 4.84 to 6.32
* I am willing to speak in front of people 4.4 to 6.12

Alum report lifelong transformation: "When 4-H Extension started 100 years ago, one of the premises was that by teaching youth proper animal husbandry and farming practices, those practices would be learned by parents. That premise still works. Because of the Beef Quality Assurance classes our two boys have had over the years, we have improved our practices with customer's cattle in our heifer development operation." Another alum reported learning to write a grant through the 4-H Foundation as a senior in high school. The grant funded the purchase of picnic tables for a public park. Many years later, those picnic tables are still in use, and since then, the 4-H alum has written many more grants professionally and for the community.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems
602	Business Management, Finance, and Taxation
801	Individual and Family Resource Management
802	Human Development and Family Well-Being
806	Youth Development
903	Communication, Education, and Information Delivery

Outcome #3

1. Outcome Measures

Leadership/Volunteer Development: Increased number of youth and adults who have received leadership training and demonstrate increased knowledge and ability as a result of the training.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	3648

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Leaders, youth and adult, are vital to the strength of 4-H programs and communities. The greater the depth of leadership within a program, the greater the likelihood that the program will be successful. Trained, caring adults matched with youth create partnerships that increase the competence, connection, confidence, compassion and character for both entities and increase the ability for clubs and communities to function at the highest level. MSU Extension is committed to training volunteers and improving their leadership skills.

What has been done
MSU Extension provided a statewide 4-H Leadership Forum which was attended by 167 volunteers. Of the 77 who completed follow-up surveys, half had volunteered 10 years or more and half were attending a Forum for the first time. Individual counties and regions also provide extensive opportunities for leadership training including volunteer certification. Youth receive hands-on leadership practice by managing all aspects of club activities from conducting needs assessments to planning programming to budgeting and finance.

Results
The state Leadership Forum provided skills and encouragement for leaders. One replied, "When we give so much to our clubs, we tend to get drained. I needed to be inspired and to just have some fun. I got this. Thank you." Each trained volunteer impacts between 20 and 36 kids, meaning this forum alone will impact as many as 6,000 youth. Individual counties report that recruiting volunteers and giving them training and certification opportunities increases participation by 50%. In one county, 31 certified adult volunteers contributed over 1,000 hours of time at an economic value of over $20,000. Statewide, there were 3,648 volunteers who contributed nearly $2 million in economic value to their community. Reports indicated that 75% of youth who participate in 4-H leadership programs also had leadership roles in school, church and other community organizations.

4. Associated Knowledge Areas

KA Code	Knowledge Area
602	Business Management, Finance, and Taxation
801	Individual and Family Resource Management
802	Human Development and Family Well-Being
806	Youth Development
903	Communication, Education, and Information Delivery

Outcome #4

1. Outcome Measures

Military Family Partnerships: Increased interaction with military families resulting in increased capacity of families to access resources and support.

Not Reporting on this Outcome Measure

Outcome #5

1. Outcome Measures

Parenting/Caregiving: Increased number of parents and caregivers who access support and resources and increased knowledge and ability of participants as a result of those efforts.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	987

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
By 2025 it is expected that more than 25% of Montana's population will be over 65 years of age. With extended life expectancy comes a variety of chronic illnesses. Research indicates high rates of depression and anxiety among caregivers, as well as increased vulnerability to health problems. In 2014, AARP estimated Montana had 118,000 unpaid caregivers providing 110 million hours of care to loved ones at a value of $1.4 billion (based on $12.97/hour). Montana is currently ranked 49/50 in services for caregivers. Extension seeks to provide increased support. More than 6600 grandparents in Montana are responsible for the primary care of their grandchildren.

What has been done
Powerful Tools for Caregivers (PTC) is an educational program that provides family caregivers with skills and confidence to better care for themselves while caring for someone with a chronic illness. The Extension PTC class trains instructors to conduct six weekly 90-minute classes in communities across Montana to empower caregivers. The Montana Grandparents Raising Grandchildren (GRG) Project provides resources for grandparent-headed families including support group facilitator training and coordination of a network of 34 education/support groups across the state, including on the seven Indian Reservations. Efforts to better reach minorities

were successful as 280 Native Americans and 90 grandfathers were included in the 600 direct contacts through this program.

Results
In 2016, 11 new trainers earned certification (through an expanded PTC version that also covered parenting children with disabilities and GrandCares) and are now serving communities statewide. One PTC participant noted, "I now know how to talk to Mom and redirect when needed. I know it's not my fault." Since grandparents often care for grandchildren informally, the state saves more than $213,000/day in foster care payments. GRG regularly reaches more than 200 grandparents directly and more than 650 through newsletters, listservs and web contacts. In part because of the support provided through MSU Extension, Montana was ranked by Generations United as one of the top 10 states for grandfamily-friendly laws and policies. GRG directly led to one grandmother attaining guardianship of her grandchildren providing both her and the parents with legal rights.

4. Associated Knowledge Areas

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

Outcome #6

1. Outcome Measures

Personal Finances: Increased number of participants in classes and training and increased knowledge and aptitude of those participants based on pre- and post- survey results. Increased number of ACA inquiries, referrals, resources developed and shared, workshops and enrollments.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	4083

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Working adults in Montana face many financial decisions. Often their only source of information about these decisions is provided by the company selling the product. Montanans of all ages can benefit from learning about the need for estate planning as 70% die without a will. The average age of farm/ranch operators is 58. During the next decade many operations will be passed down

to the next generation. It is critical that people understand how property is titled and who receives it if they die without writing a will.

What has been done

MSU Extension provides educational programming, MontGuides, radio programs and newspaper articles to bring unbiased information to Montanans. In 2016 targeted audiences included the Young Ag Couples Conference, MSU and MSU Billings alumni, the Montana Department of Agriculture, County Conservation Districts, Community Foundations and more. Estate planning workshops reached 2846 adults in 47 presentations. From 60-89% of these individuals did not have an estate plan in place before attending. Solid Finances programming reached 1237 in 23 presentations ranging from "Health Care Savings Accounts and Flexible Spending Accounts" to "Home Mortgage Refinancing" to "Transferring your Farm" and "Recent Changes to Federal Financial Aid."

Results

Estate planning participants reported intent to:
- 94% discuss estate planning with their spouse and/or other family members
- 90% review their property ownership titles
- 70% write a separate listing of tangible personal property to attach to their will
- 91% review their beneficiary designations on their assets

Solid Finances participants reported:
- 31% created an emergency fund
- 36% set retirement goals
- 59% created a personal financial net worth statement
- 94% took at least one action to protect themselves.

Having dependable, non-biased financial education helps Montanans be financially stable and reduces the likelihood they will need government provided financial support programs in the future. Estate planning helps prevent families from fracturing while peacefully transferring property from generation to generation.

4. Associated Knowledge Areas

KA Code	Knowledge Area
602	Business Management, Finance, and Taxation
801	Individual and Family Resource Management
802	Human Development and Family Well-Being
903	Communication, Education, and Information Delivery

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 Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

The Montana 4-H office continues to have a reduced staff which has slowed the progress of creating enhanced evaluation tools. Nevertheless, a pilot was completed on evaluating both Communication Skills and Community Involvement. These pilots will be expanded in 2017.
Military Programs continued in Yellowstone, Lewis and Clark and Cascade counties, but with no grant funding they operated as traditional clubs with no separate reporting.
Since we are using the same Plan of Work as last year, we weren't able to correct our poor output measures which were written in an ambiguous or non-quantitative manner. This will be improved when feasible.
For this year, output one is the total number of offices statewide that have 4-H programs, output two is the number of unique projects that were offered in Montana 4-H and had at least one participant, output three is each of the statewide 4-H offices plus two statewide training opportunities, output five is the number of Grandparents Raising Grandchildren support networks and output six is the number of participants in financial training.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

MSU Extension recognizes that families come in a variety of configurations and offers resources and training to assist them in navigating all the various stages and changes that occur across generations. Montanans desire resources to support youth and that help them to become better caregivers for the elderly and disabled friends and family. They seek resources for successfully parenting grandchildren and for managing their own aging process, including planning for transfer of wealth and managing personal finances. MSU Extension is fully engaged in meeting needs in every county and on every reservation for all Montanans, across generations.

Key Items of Evaluation

- Extension facilitated all kindergarten students in Hamilton receiving a savings account from a local organization and provided them saving education.
- 135 individuals were certified through Intermountain Livestock Judges Training and judged 823 county shows, 43 state shows and 36 regional shows.
- 4-H Alum testimonials:
  - "When 4-H Extension started 100 years ago, one of the premises was that by teaching youth proper animal husbandry and farming practices, those practices would be learned by parents. That premise still works. Because of the Beef Quality Assurance classes

our two boys have had, we have improved our practices with customer's cattle in our heifer development operation."

- Another alum reported learning to write a grant through the 4-H Foundation as a senior in high school. The grant funded the purchase of picnic tables for a public park. Many years later, those picnic tables are still in use, and the 4-H alum has written many more grants professionally and for the community.
- Youth on the Flathead Reservation gained technical skills in videography and editing. They took footage of tours of Ninepipes Reservoir, prehistoric Lake Missoula, Bozeman and Butte and then debuted their edited creations in a celebration with tribal elders.
- Three counties piloting a communication skills evaluation reported youth increased ability from before starting 4-H to after, based on an ascending 1-7 scale (1 strongly disagree, 7 strongly agree).
  - I know how to prepare a presentation: 3.76 to 6.04
  - I am willing to speak in front of people 4.4 to 6.12
- Individual counties report that training and certifying youth volunteers increases their participation by 50%.
- Statewide, there were 3,648 4-H volunteers who contributed nearly $2 million in economic value to their community.
- Reports indicated that 75% of youth who participated in 4-H leadership programs also had leadership roles in school, church and other community organizations.
- 11 new trainers earned Powerful Tools for Caregivers certification (through an expanded PTC version that also covered parenting children with disabilities and GrandCares).
- Since grandparents often care for grandchildren informally, the state saves more than $213,000/day in foster care payments.
- GRG regularly reaches more than 200 grandparents directly and more than 650 through newsletters, listservs and web contacts.
- In part because of the support provided through MSU Extension, Montana was ranked by Generations United as one of the top 10 states for grandfamily-friendly laws and policies.
- GRG directly led to one grandmother attaining guardianship of her grandchildren providing both her and the parents with legal rights.
- Estate planning participants reported intent to:
  - 94% discuss estate planning with their spouse and/or other family members
  - 90% review their property ownership titles
  - 70% write a separate listing of tangible personal property to attach to their will
  - 91% review their beneficiary designations on their assets.
- Solid Finances participants reported:
  - 31% created an emergency fund
  - 36% set retirement goals
  - 59% created a personal financial net worth statement
  - 94% took at least one action to protect themselves.

V(A). Planned Program (Summary)

Program # 7

1. Name of the Planned Program

Healthy Living, Nutrition and Food Safety

☑ 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
701	Nutrient Composition of Food	5%		10%	
702	Requirements and Function of Nutrients and Other Food Components	5%		5%	
703	Nutrition Education and Behavior	20%		0%	
704	Nutrition and Hunger in the Population	10%		30%	
721	Insects and Other Pests Affecting Humans	5%		25%	
722	Zoonotic Diseases and Parasites Affecting Humans	5%		30%	
724	Healthy Lifestyle	20%		0%	
801	Individual and Family Resource Management	10%		0%	
802	Human Development and Family Well-Being	10%		0%	
805	Community Institutions, Health, and Social Services	10%		0%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	4.0	0.0	6.3	0.0
Actual Paid	6.0	0.0	4.1	0.0
Actual Volunteer	3.2	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**
182863	0	67522	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	262874	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
87082	0	202309	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Conducted train the trainer workshops
- Conducted workshops, seminars, meetings
- Facilitated meetings, discussion groups, focus groups
- Developed local and state partnerships
- Developed MontGuides (fact sheets), publications, website materials, video based materials
- Conducted web based, interactive training/education opportunities
- Researched sustainable solutions to problems affecting bee health (Food Supply)
- Mitigated the antibiotic resistance reservoir with bacterial plasmid curing agents (Food Safety)
- Researched food quality and metabolic parameters influencing development of progression of Fatty Liver Disease
- Investigated the marketing and delivery of quality grains and BioProcess Coproducts (Food Safety)
- Researched nutrient bioavailablity-phytonutrients and beyond (Food Safety)

2. Brief description of the target audience

- Low income adults
- Low income youth
- Adults that are FSP eligible
- Youth from FSP eligible households
- Teachers in the Montana School System
- Middle to older aged women, especially those living in rural areas
- Parents and youth living in rural areas
- Working people
- Elderly and shut-in people
- Reservation youth
- Food service managers and staff

3. How was eXtension used?

eXtension was used for newsletters, fact sheets, general resources and evaluation tools and reports.

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	7549	60092	8574	9547

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

Patent Applications Submitted

Year:	2016
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	8	20	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Healthy Lifestyles: Classes and resources, printed and online, are readily available to Montanans to increase knowledge related to physical activities and the need for proactive medical testing.

Year	Actual
2016	56

Output #2

Output Measure

- Nutrition: Classes, publications and online resources are utilized to provide current information regarding nutrition, food resource management tools and other dietary needs directly to Montanans.

Year	Actual
2016	56

Output #3

Output Measure

- EFNEP/SNAP-Ed: The NEP curriculum is utilized to teach qualifying adults and youth a series of lessons related to nutrition and food resource management.

Year	Actual
2016	6889

Output #4

Output Measure

- Food Safety: County Agents are trained to offer food safety education classes and ServSafe training to local sanitarians, school and public food service personnel, volunteers and others.

Year	Actual
2016	56

Output #5

Output Measure

- Food Preservation: Training and updates for County Extension Agents equip them to conduct educational programs, test equipment and answer questions.

Year	Actual
2016	56

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Healthy Lifestyles: Increased participation in healthy lifestyle programming and health monitoring that leads to healthy lifestyle choices.
2	Nutrition: Increased participation in nutrition classes, training and use of online and printed resources leading to measureable changes in nutrition habits.
3	SNAP-Ed: Increased participation by eligible SNAP recipients leading to increased knowledge and behavior change related to nutrition, food resource management, food safety and physical activity. EFNEP: Increased participation by eligible low-income families with young children, pregnant woman and teens, leading to increased knowledge and behavior change related to nutrition, food resource management, food safety and physical activity.
4	Food Safety: Increased participation in food safety classes, trainings and increased knowledge, utilization and certifications earned by participants.
5	Food Preservation: Increased participation in food preservation classes and increased knowledge and utilization of concepts learned by participants.
6	Food Security: Sustainable Solutions to Problems Affecting Bee Health

Outcome #1

1. Outcome Measures

Healthy Lifestyles: Increased participation in healthy lifestyle programming and health monitoring that leads to healthy lifestyle choices.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	748

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Chronic diseases are Montana's leading cause of death, illness and disability and account for 70 percent of healthcare costs. In Montana, heart disease is the leading cause of death, and the number one complication of diabetes. Statistics show that 29.1 million Americans, or one in every 11 people, have diabetes. The percentage of Americans age 65 and older remains high, at 25.9%, or 11.8 million seniors (diagnosed and undiagnosed). 1.4 million Americans are diagnosed with diabetes every year. Additionally, Native American population groups are at higher risk of developing diabetes. Since there are seven reservations located within the boundaries of our state, the need for diabetes education in Montana was identified as paramount.

What has been done
The Diabetes Empowerment Education Program (DEEP) is an evidence based diabetes self-management program developed by the University of Illinois, Chicago that has been shown to be successful in helping participants take control of their disease and reduce the risk of life threatening complications. MSU Extension partnered with Mountain Pacific Quality Health, Stillwater Billings Clinic, The Montana Geriatric Center of the University of Montana and the Montana Department of Health and Human Services to expand the implementation to Montana counties and reservations. To date, 48 Extension agents and health care providers in 26 counties have been trained as facilitators, and 334 participants have submitted pre and post test results.

Results
Clinical data show initial results of the DEEP program with significant improvement in two areas. HbA1c levels represent the average blood sugar a person has over a three month time period. Thus far data reveals participants in the DEEP program saw their A1c levels drop from an average of 8.2 to 7%. A recommended goal for most people with diabetes is 7%, so this drop in A1c levels is very significant. The second area of improvement is systolic blood pressure levels

which participants decreased by 10 points, showing strong evidence of the effectiveness of the DEEP diabetes program. Additionally, upon completion of the program, participant eye exams increased from 25% to 37.5% with participants reporting they completed annual eye exams, a recommended part of the program. Foot exams and annual blood draws are also expected to increase after attending the program and that data is currently being collected. Community partners assisted with revising the curriculum, developing six lesson plans catered to Extension delivery methods and achieved necessary funding.

4. Associated Knowledge Areas

KA Code	Knowledge Area
703	Nutrition Education and Behavior
704	Nutrition and Hunger in the Population
724	Healthy Lifestyle
801	Individual and Family Resource Management
802	Human Development and Family Well-Being
805	Community Institutions, Health, and Social Services

Outcome #2

1. Outcome Measures

Nutrition: Increased participation in nutrition classes, training and use of online and printed resources leading to measureable changes in nutrition habits.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	1028

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
There is a need for horticulture and gardening programming in Montana. According to the Montana Food Bank, 30 of Montana's 56 counties have areas considered food deserts. During the growing season, calls to a county Extension office are over 50 percent horticulture- or IPM-related and in some counties, upwards of 90 percent. Master Gardener curriculum educates the general public in horticulture, yard and garden maintenance and IPM. The Master Gardener program requires participants to volunteer as a condition of becoming certified. Increasing the

ability for citizens to access or grow their own sustainable, local foods is a priority for MAES, COA and Extension.

What has been done

The Master Gardener program has three levels: Level 1 includes basic and intermediate curriculum, Level 2 includes a large emphasis on IPM and Level 3 is a three-day intensive training held on the MSU campus in Bozeman. In addition, many counties offer horticulture classes and projects to meet the direct needs of their communities. Agents respond to drop-ins, phone calls and emails and many offer weekly columns or set up booths at Farmers' markets to answer questions. Many towns have thriving community gardens as a result of Extension horticulture programs, including Master Gardeners. In 2016 more than two tons of food was donated to local food banks. There were 1,028 active Master Gardeners, 715 certified in 41 counties and 2 reservations. They volunteered 12,893 hours, valued at $303,759.

Results

An example of the long term change in condition that happens when empowering communities with food sustainability is in Eastern Montana. Through the Community GATE (Giving Assistance Towards Employment) program, grants were received to create the Food Development Center commercial kitchen and Farm-to-Table Store at the Eastern Plains Event Center. The commercial kitchen allows entrepreneurs, including caterers and small business owners, to safely prepare foods and sell their products. These programs have increased the vitality of communities within a 150-mile radius of Glendive, including 16 Montana counties and 13 North Dakota counties, by bringing together growers, value-added producers, restaurants, stores, institutional food services, schools, individual consumers and community partners to create an emerging local food system. Extension is integral in coordinating these efforts to facilitate the development of profitable and sustainable ag-based local food systems. The Fort Belknap Sustainable Food Program, described under Community Development, is another example of how Extension facilitates this important process of increasing access to healthy food.

4. Associated Knowledge Areas

KA Code	Knowledge Area
701	Nutrient Composition of Food
702	Requirements and Function of Nutrients and Other Food Components
703	Nutrition Education and Behavior
704	Nutrition and Hunger in the Population
724	Healthy Lifestyle
801	Individual and Family Resource Management
802	Human Development and Family Well-Being
805	Community Institutions, Health, and Social Services

Outcome #3

1. Outcome Measures

SNAP-Ed: Increased participation by eligible SNAP recipients leading to increased knowledge and behavior change related to nutrition, food resource management, food safety and physical activity.
EFNEP: Increased participation by eligible low-income families with young children, pregnant woman and teens, leading to increased knowledge and behavior change related to nutrition, food resource management, food safety and physical activity.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	6889

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Food insecurity and hunger is prevalent in Montana. One in nine Montanans face hunger/food insecurity; 29% of Montana children and 61% of adults are overweight or obese (74% of American Indian Montana adults); 20% of Montana adults eat less than one serving of vegetables a day; and 77% of Montana adults do not get enough aerobic and muscle-strengthening exercises to meet guidelines. Accessing affordable, healthy foods is a challenge and can result in obesity and health issues. Nutrition education helps Montanans learn how to stretch their food dollars while meeting USDA dietary guidelines.

What has been done
MSU Extension administers Montana's Expanded Food and Nutrition Education Program (EFNEP) and Supplemental Nutrition Access Program Education (SNAP-Ed). EFNEP serves very low-income families who reside in Billings and Missoula and is funded through a USDA-NIFA Grant. SNAP-Ed is funded through a USDA Food and Nutrition Service grant through the Montana Department of Health and Human Services. Families who qualify for government benefits are eligible to participate in the educational series. EFNEP and SNAP-Ed directly reached 6,889 youth and adults in 2016. Lessons included budgeting and tips for purchasing and preparing healthy food and incorporating more physical activity for adults and choosing healthy foods and learning fun physical activities for kids.

Results
EFNEP adults who made improvements in the following areas: don't run out of food before the end of the month 63%; improved their physical activity 74%; improved in one or more nutrition practices taught in the class 97%, improved in one or more food resource management practices

(plan meals, compare prices, use grocery list, etc) 95%. Percent of children who made improvements: diet quality 87%; physical activity 39%. SNAP-Ed specific behaviors improved (adults): don't run out of food before the end of the month 25%; frequency of activity 43%; improved one of more food resource management practices 71%; and use of nutrition practices taught in class 80%. SNAP-Ed improved behaviors (children): diet quality 76%, physical activity 24%. One family of seven reported they learned skills to reduce their grocery bill by $150/month, dramatically reduced intake of sugar sweetened beverages, and committed to serving vegetables twice a day. Because of their new skills and changed behavior, they are healthier overall. A Title 1 school now has six raised bed gardens where students are growing, harvesting, preparing and eating vegetables.

4. Associated Knowledge Areas

KA Code	Knowledge Area
702	Requirements and Function of Nutrients and Other Food Components
703	Nutrition Education and Behavior
704	Nutrition and Hunger in the Population
724	Healthy Lifestyle
801	Individual and Family Resource Management
802	Human Development and Family Well-Being
805	Community Institutions, Health, and Social Services

Outcome #4

1. Outcome Measures

Food Safety: Increased participation in food safety classes, trainings and increased knowledge, utilization and certifications earned by participants.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	471

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Each year in America there are over 48 million documented cases of food-borne illness. The financial cost of food-borne illness is tremendous, including lost wages, healthcare and investigative costs. Basic food safety training on controlling time and temperature when handling

food, and ensuring proper cleaning and sanitizing reduces the incidence of food-borne illness. Many food service groups, including school systems, Head Start and food banks, now require food safety training. In January of 2015, the state of Montana Rule for Retail Food Establishments went into effect requiring additional training for retail employees and volunteers serving food.

What has been done
ServSafe is the educational program of the National Restaurant Association and is widely recognized throughout the United States. Extension professionals from at least 15 counties or reservations are certified trainers of this program. They provided dozens of 2-hour/Level 1, 4-hour/Level 2 and 8-hour/Level 3 sessions to 1,437 individuals. Depending on the level, participants learn: controlling time and temperature; ensuring proper personal hygiene; preventing cross-contamination; proper cleaning and sanitizing; the impact of safety on an operation; the flow of food through an operation and managing a food-safe operation.

Results
Northern Cheyenne Extension, Northern Cheyenne Tribal Health and the Rosebud-Treasure County Extension came together to update the tribal food code to create stricter guidelines and requirements. Seventy-four participants took ServSafe Level 3 classes, thus increasing their opportunity for employment and increasing the safety of the community's retail establishments and public events where food is served. The reservation sanitarian reported overall improved safety practices. Youth at Pine Hills Youth Correctional Facility receive ServSafe training which gives them valuable and marketable skills to help them find employment following release. Statewide nearly 2,000 people have been trained since the new law went into effect. Nearly 100 percent passed Level 1 and 2 certifications while approximately 90 percent passed the Level 3 Food Safety Manager certification. Certification increases employability, brings about improved safety, not only at retail locations, but also at concession stands, farmer's markets and retail establishments.

4. Associated Knowledge Areas

KA Code	Knowledge Area
702	Requirements and Function of Nutrients and Other Food Components
703	Nutrition Education and Behavior
704	Nutrition and Hunger in the Population
801	Individual and Family Resource Management
802	Human Development and Family Well-Being
805	Community Institutions, Health, and Social Services

Outcome #5

1. Outcome Measures

Food Preservation: Increased participation in food preservation classes and increased knowledge and utilization of concepts learned by participants.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	471

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Montana has abundance of nutritious, seasonal, wild and homegrown foods. Sustainable food trends, the economy, and presence of food deserts across Montana have all increased interest in home food preservation as an important and popular activity. Recent national surveys reveal that a high percentage of home food processors are using practices that put them at high risk for food-borne illness and economic loss due to food spoilage. MSU Extension has long been recognized as a credible source for science-based recommendations for home food preservation.

What has been done
Extension utilizes many strategies for educating the public about safe food preservation. Every office responds to drop-in visitors, phone calls and emails asking individual questions. MontGuides, fact sheets and other resources are distributed during county fairs, farmer's markets, community events and during trainings. Classes covering topics such as canning; water bath canning; meat preserving and canning; pickling, freezing; drying and the science of food-borne illnesses and how to prevent them, are offered in communities all across the state. Extension faculty share information through newspaper articles, blogs, listservs, newsletters, radio spots, and social media and pressure-gauge testing at local hardware and grocery stores. Extension is working on customizing the WSU Master Food Preserver curriculum.

Results
Food preservation is a strength of MSU Extension programming, however, there isn't a strong central unit to oversee evaluation and reporting in this area so we lack data. Participants in eight classes in Missoula County reported: 95% learned a new technique or gained confidence; 90% wanted more classes on pressure canning, making pickled products and dehydrating. Extension complied and of those, 90% attended the classes within 6 months. The County reported strengthening community partnerships through canning as the local foods movement is strong in the area. They are partnering with the Missoula Urban Indian Health Center horticulturist to continue improving healthy eating/food preservation in Native populations. In Lewis and Clark County 100% of participants indicated they felt comfortable using at least one new skill they learned in class at home. One participant said, "I've been canning in Montana for 20 years and had no idea I had to adjust for altitude." This county also noted strengthening community partnerships and raising awareness of other Extension programs through markets, Public Health offices and more. Six more individuals became Master Food Preservers.

4. Associated Knowledge Areas

KA Code	Knowledge Area
701	Nutrient Composition of Food
702	Requirements and Function of Nutrients and Other Food Components
703	Nutrition Education and Behavior
704	Nutrition and Hunger in the Population
724	Healthy Lifestyle
801	Individual and Family Resource Management
802	Human Development and Family Well-Being
805	Community Institutions, Health, and Social Services

Outcome #6

1. Outcome Measures

Food Security: Sustainable Solutions to Problems Affecting Bee Health

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Honey and bumble bees are a critical pollinator of the world's major crops and therefore, sustain the nation and world's food security and supply. Montana has the most species of bumble bees of any state in the nation and has the second-highest number of honey bees in the county. Montana is also the country's top producer of honey. Montana open lands and forages provide an open and healthy ecosystem for these critical pollinators to breed, flourish and pollinate. However, unknown causes of honey and bumble bee deaths are occurring globally, as the world is seeing a global decline in bee populations.

What has been done
The Flenniken Lab investigates the role of biotic and abiotic factors on honey bee health at both the individual bee and colony level. This research includes both field and laboratory based studies. The role of causative mechanisms of parasitic mites, viruses, and microbes in pollinator abundance and honey bee colony success was researched, in addition to assessing the effects of exposure to pesticides and other xenobiotics on the survival, health and productivity of honey bee

colonies and pollinator abundance and diversity.

Results

Effects of interactions among various factors affecting pollinator and honey bee colony health. Evaluated the role and causative mechanisms of parasitic mites, viruses, and microbes in pollinator abudance and honey bee colony success. Assessed the effects of exposure to pesticides and other xenobiotics on the survival, health and productivity of honey bee colonies and pollinator abudance and diversity, determined the effects of interactions among various factors affecting pollinator bee colony health. Ongoing projects and progress was presented at the American Bee Research Conference in Jan 2016. Three undergraduates and three graduate students were trained and mentored on the relationship between pathogens and colony health and honey bee antiviral defense mechanisms.

4. Associated Knowledge Areas

KA Code	Knowledge Area
721	Insects and Other Pests Affecting Humans
722	Zoonotic Diseases and Parasites Affecting Humans

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

Brief Explanation

MSU Extension utilizes train-the-trainer methods to reach more people with limited resources. Data from classes taught by Extension volunteers is not always easy to access, though is clearly an impact of Extension work. MSU Extension is continuing to work with faculty on creating effective evaluation tools and improving methods for gathering qualitative outcomes. COA/MAES research in this program area has largely been absorbed into new Hatch Projects in the areas of Food Safety and Security, which are not reflected in the auto-populated outcome sections of this Annual Report. Unfortunately, many of these research highlights are unable to be described in detail in regard to impact and outcome, given the limited software process of the annual report, which correlates only with the previous POW report. Naturally, this lapse misses quite a large portion of new and ongoing Hatch research. We are looking forward to the new software being developed for 2017 reporting.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Evaluation tools most utilized were pre- and post- surveys. MSU Extension continues to work on improving the skills of faculty related to conducting needs assessments, improving strategic planning, developing stronger evaluation tools, and maximizing data collection.
When writing the 2016 Plan of Work, we created output measures that weren't quantitative, tried to measure multiple things, or asked to measure things that are very difficult to track. We will correct these statements in the next Plan of Work. IN the meantime we attempted to include the outputs within the outcomes to demonstrated successful completion of the intended outputs.
One program in which MSU Extension had particular impact, was the multi-state, integrated Strong Hearths, Healthy Communities (SHHC): a rural community-based cardiovascular disease prevention program. Cardiovascular disease is the leading cause of death in the United States and places substantial burden on the healthcare system. Rural populations have considerably higher rates of the disease. SHHC aimed to reduce disease morbidity and mortality, improve quality of life and reduce the cardiovascular disease-related health burden in underserved rural communities.
There were seven focus groups that included 54 sedentary, overweight/obese men aged 43-88 who resided in medically underserved rural Montana towns. There were 17 focus groups with 125 sedentary/overweight/obese adults aged 40-91 who resided in medically underserved rural Montana towns.
Intervention Results - Summary
SHHC participants had statistically significant improvements in some measures of body composition, physical activity, physical function, and diet compared to control participants (SHHW):
Baseline to Midpoint: weight, waist to hip ration, BMI

Baseline to Outcome (Pre to Post):weight, BMI, C-Reactive Protein, Simple 7, Minutes of moderate to vigorous physical activity per day, Number of steps during Two-Minute Step Test, Cups of fruit per day.
Fruit and Vegetable Results: Consumption of fruit and vegetables was generally low by all measures.
24-hour recall: 19% consumed adequate fruit, 21% consumed adequate vegetables
Questionnaire:
31% consumed recommended fruit
37% consumed the recommended amount of vegetables
Some measures of the 24-hour recall and questionnaire correlated with skin scan measures, but others did not, particularly for vegetables.
Healthy Eating Index:
o Only 6 participants (3.5%) had a baseline Healthy Eating Index score that indicated good diet quality.
o Perceiving fruits, vegetables, and low-fat foods as easy to purchase in the community and perceiving there to be a large selection of high-quality low-fat foods in the community were associated with a non-poor diet.
o Eating out frequently at restaurants and shopping at the farmers' market were also associated with a better diet.
Studies such as this have ongoing importance in rural Montana as the population struggles with provider shortages.

Key Items of Evaluation

- Initial results of the DEEP program:
  - Participants saw their A1c levels drop from an average of 8.2 to 7%.

- Systolic blood pressure levels decreased by 10 points
- Participant eye exams increased from 25% to 37.5%

- Through the Community GATE (Giving Assistance Towards Employment) program, grants were received to create the Food Development Center commercial kitchen and Farm-to-Table Store at the Eastern Plains Event Center. The commercial kitchen allows entrepreneurs to safely prepare foods and sell their products, increasing the vitality of communities within a 150-mile radius of Glendive, including 16 Montana counties and 13 North Dakota counties, by bringing together growers, value-added producers, restaurants, stores, institutional food services, schools, individual consumers and community partners to create an emerging local food system.
- EFNEP adults:
  - don't run out of food before the end of the month 63%
  - frequency of physical activity 74%
  - improved nutrition practices taught in the class 97%
  - improved food resource management practices (plan meals, compare prices, use grocery list, etc) 95%
- EFNEP children:
  - diet quality 87%
  - physical activity 39%
- SNAP-Ed specific behaviors improved (adults):
  - don't run out of food before the end of the month 25%
  - frequency of activity 43%
  - improved food resource management practices 71%
  - Used nutrition practices taught in class 80%
- SNAP-Ed improved behaviors (children):
  - diet quality 76%
  - physical activity 24%
- One SNAP-Ed family of seven learned skills to reduce grocery bill by $150/month, dramatically reduced intake of sugar sweetened beverages, and served vegetables twice a day.
- Northern Cheyenne Extension, Northern Cheyenne Tribal Health and the Rosebud-Treasure County Extension:
  - Updated the tribal food code to create stricter guidelines and requirements
  - 74 participants took ServSafe Level 3 classes
  - The reservation sanitarian reported overall improved safety practices.
- Youth at Pine Hills Youth Correctional Facility received ServSafe training giving them valuable and marketable skills to help find employment following release.
- Nearly 2,000 people received ServSafe training statewide. Certification increases employability and improves food safety at retail locations, concession stands, farmer's markets.
- Missoula County reported that participants in eight food preservation classes:
  - learned a new technique or gained confidence 95%
  - wanted more classes on pressure canning 90%; Extension provided more classes
- Six more individuals became Master Food Preservers.
- Bee research:
  - Evaluated the role and causative mechanisms of parasitic mites, viruses, and microbes in pollinator abundance and honey bee colony success
  - Assessed the effects of exposure to pesticides and other xenobiotics on the survival of honey bee colonies
  - Determined the effects of interactions among factors affecting pollinator bee colony health

- Presented at the American Bee Research Conference in Jan 2016. Six students were trained and mentored on the relationship between pathogens and colony health and honey bee antiviral defense mechanisms

V(A). Planned Program (Summary)

Program # 8

1. Name of the Planned Program

Community Development

☑ 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	30%		0%	
704	Nutrition and Hunger in the Population	20%		0%	
723	Hazards to Human Health and Safety	10%		0%	
803	Sociological and Technological Change Affecting Individuals, Families, and Communities	10%		0%	
805	Community Institutions, Health, and Social Services	20%		0%	
902	Administration of Projects and Programs	10%		0%	
	Total	100%		0%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2016	Extension		Research	
	1862	1890	1862	1890
Plan	3.5	0.0	0.0	0.0
Actual Paid	3.1	0.0	0.0	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**
78763	0	0	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	0	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
76064	0	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

• Community meetings were held to determine community values, attitudes and vision on which to develop strategies and action plans.
• Partnered with local economic development entities, agencies, businesses/industry and organizations to implement goals and plans of action.
• Planned for potential disasters that may occur in a community, e.g., EDEN.
• Provided training opportunities available for people serving on boards, councils and committees in both the public and private sectors.
• Hosted culturally-sensitive meetings with tribal leaders focused on community development.

2. Brief description of the target audience

• Business and Community Leaders
• Local Development Entities
• Chamber of Commerce Members
• Tourism Leadership - local/state
• County and City Government
• County DES, Law Enforcement Emergency Response Coordinators
• Current community leadership/potential community leaders
• Landowners
• Adults/Youth serving on Boards
• Elected officials
• Tribal members

3. How was eXtension used?

eXtension was used to access Extension communities of practice, the Extension Disaster Education Network and other resources and planning and evaluation tools.

V(E). Planned Program (Outputs)

1. Standard output measures

2016	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	11531	38300	1204	1266

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

Patent Applications Submitted

Year:	2016
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2016	Extension	Research	Total
Actual	0	0	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Community Resource Development: Community Foundations, endowments or similar collaborations receive training and assistance focused on keeping wealth within the community to be used toward common strategic initiatives.

Year	Actual
2016	7

Output #2

Output Measure

- Governance and Citizen Leadership: Number of trainings offered through Extension Community Development and the MSU Extension Local Government Center to elected and public officials and volunteers.

Year	Actual
2016	7000

Output #3

Output Measure

- Emergency/Disaster Planning and Management: Workshops, presentations, and other assistance offered in support of Emergency/Disaster Planning and Management to create disaster response plans.

Year	Actual
2016	17

Output #4

Output Measure

- Community Development with Tribal Populations: Number of collaborations with tribes focused on community development issues. Workshops, presentations and assistance offered to tribal populations in forming collaborations focused on community development issues.

Year	Actual
2016	5

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Community Resource Development: Increased participation of community members toward supporting established community priorities with a resulting increase in the number of Community Foundations and endowments.
2	Citizen Leadership and Good Governance: Increased number of people serving on boards, councils and/or committees who are trained and prepared for the responsibilities/authorities of the entity.
3	Emergency/Disaster Planning and Management: Increased number of communities creating and updating clear disaster mitigation plans with effective and efficient leadership by Extension personnel.
4	Community Development with Tribal Populations: Increased number of collaborations with tribes to address specific community development priorities.

Outcome #1

1. Outcome Measures

Community Resource Development: Increased participation of community members toward supporting established community priorities with a resulting increase in the number of Community Foundations and endowments.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	2492

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
According to the Center for Rural Entrepreneurship, Montanans will be transferring $12 billion of wealth between generations by 2020. By 2030, it is estimated that 25 percent of the population will be age 65 or older. Many heirs of this generation no longer live within Montana. As a result, much of Montana's estimated wealth may leave if there isn't an effort to retain it; and one way to do that is through development of community foundations.

What has been done
MSU Extension has trained agents and community leaders to grow and build community foundations. They have provided workshops ranging from grant writing and raising funds, to increasing leadership abilities to improving relationships and engaging community members. MSU Extension has helped local foundations create long-range, strategic plans for Montana communities to develop in a thoughtful manner. Seven counties indicated extensive work by their local agents in preserving assets for community improvements. In 2016, these agents worked with 247 volunteers to directly connect with 2,245 local community members.

Results
Glacier County: Rated "least healthy" in Montana. Secured $88,917 ($33,466 in 2016) and completed the first two routes of the Cut Bank Walking Trail. Jefferson County: After the 2015 Montana Legislature closed the Montana Development Center which employed 250 people (Boulder's population is 1,200), Extension formed the Boulder Transition Advisory Committee which created a master plan for community sustainability and is beginning implementation. Stillwater County: Extension leads the Stillwater County Library and Community Center Steering Committee which raised $40,000 in 2016, completed a conceptual design and hired capital campaign consultant. Wheatland County: Extension received $112,000 worth of grants to fund the Chief Joseph Park playground project and the first two phases are complete. Liberty County:

Raised $3,000 toward endowment and hosted two board leadership trainings attended by 40 people from 20 different volunteer governing and advisory boards. Rosebud-Treasure Counties: Completed construction, after years of planning and fundraising, of new Livestock Facility at Rosebud County Fairgrounds.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development
704	Nutrition and Hunger in the Population
803	Sociological and Technological Change Affecting Individuals, Families, and Communities
805	Community Institutions, Health, and Social Services
902	Administration of Projects and Programs

Outcome #2

1. Outcome Measures

Citizen Leadership and Good Governance: Increased number of people serving on boards, councils and/or committees who are trained and prepared for the responsibilities/authorities of the entity.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	7000

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Montana county and municipal officials are responsible for more than $1.2 billion in public funds and more than 11,000 employees. Many of these public servants have little or no training for those roles and responsibilities, human resources, public meeting laws or budgeting and financing. The MSU Extension Local Government Center (LGC) provides the only training and technical assistance of its kind for Montana municipal and county elected officials and employees.

What has been done
The MSU Extension LGC offers more than 120 affordable professional development workshops each year with over 7,000 direct contacts. Over 90 percent of Montana's clerks of district court complete a 40-hour (4-year) certification program and over 70 percent of municipal clerks, treasurers and finance officers participate in a 120 hour (4-year) certification program. In addition,

the MSU Extension LGC provided more than 750 hours of technical assistance to municipal and county government officials last year. The LGC has expanded trainings 170% in the last five years.

Results
The 2016 Municipal Institute included 103 clerks and treasurers and 53 elected officials. Overall the program was rated 4.49/5.00. Testimonials include:
* The rules local governments have to abide by are far more grueling than a private business. The LGC keeps, not only clerks, but mayors and councils informed. - Finance Officer, Conrad, MT
* The LGC provides crucial training and technical assistance for counties, and in Lewis and Clark County, it is evident that we have benefited as a result of competent LGC guidance. - Lewis and Clark County Commissioner
* The LGC is a valuable resource for our local government and one we will continue to utilize into the future. - Anaconda-Deer Lodge Clerk of Commission
The LGC distributed seven publications in 2016 and managed eight listservs which regularly reached more than 7100 emails with timely information to assist in the regular operation of governments and boards.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development
803	Sociological and Technological Change Affecting Individuals, Families, and Communities
805	Community Institutions, Health, and Social Services
902	Administration of Projects and Programs

Outcome #3

1. Outcome Measures

Emergency/Disaster Planning and Management: Increased number of communities creating and updating clear disaster mitigation plans with effective and efficient leadership by Extension personnel.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	384

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
During Hurricane Katrina, thousands of pets and animals were abandoned due, in part, to lack of planning to evacuate and shelter them. As a result, the Stafford Act was amended by Congress to require states who seek Federal Emergency Management Agency (FEMA) assistance to plan accommodations for pets and service animals as a component of their plans for evacuation of residents. Also, because Montana is a heavy livestock state and animals are frequently being transported, there are two or three accidents every year that involve livestock.

What has been done
MSU Extension received grant funding from the State Homeland Security office to create Community Animal Response Teams (CARTs) in six communities/regions. CARTs consist of volunteers who are trained and credentialed as part of existing, organized county or tribal response teams. To date two jurisdictions have begun working on their plans. Citizens in Corvallis and Hamilton came together after the Roaring Lion Fire to create an equine rescue group, livestock group and pet group. Another CART was started in Glacier, Pondera and Toole counties. Extension also hosted "Operation Rolling Cow" training which included tabletop exercises, videos, discussion and instruction. Attendees included: Montana Highway Patrol, rural EMS, County Sheriff's office personnel, veterinarians and others.

Results
Two communities practiced Operation Rolling Cow exercises. Several years ago, agencies across the state got together to create an outline for what the general response to a livestock trailer accident should be. The local communities then personalized the plan by building a resource list of departments to call, as well as people available to help with veterinary care, portable fencing, short-term loans of equipment or pasture, etc. These actions will improve safety of livestock and first responders during future accidents.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development
723	Hazards to Human Health and Safety
805	Community Institutions, Health, and Social Services
902	Administration of Projects and Programs

Outcome #4

1. Outcome Measures

Community Development with Tribal Populations: Increased number of collaborations with tribes to address specific community development priorities.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2016	1166

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
On the Blackfeet Reservation, success of the Charging Home Stampede Fair was a priority. The Blackfeet Tribe and Blackfeet Conservation District also needed to conduct an environmental assessment as the first step in renewing tribal agriculture production as part of a comprehensive economic development strategy. There are 480 individuals producing around 50,000 beef cows on the reservation who could benefit from having a strategic economic plan. On the Fort Belknap Reservation, food scarcity and economic development were needs.

What has been done
Blackfeet Reservation: Recruited 26 volunteers to improve the Charging Home Stampede Fair. Worked with the Blackfeet Tribal Business Council and the Blood Tribe and Blackfoot Confederacy in Standoff Alberta, Canada to develop projects that protect and enhance the environment. Coordinated a producer's meeting that reached 61 tribal members. Fort Belknap Reservation: The Fort Belknap Livestock Marketing Cooperative's new board is holding regular meetings and the livestock scale has been re-certified. Extension provided supplies and education to the Hays Community Garden and Lodge Pole/Red Paint Creek Community Garden and support for education and tours at the well-established experimental Aaniiih Nakoda College Garden which is produced by the Tribal College Extension office.

Results
Charging Home Stampede volunteers raised $6,400 to build an addition onto the existing 4-H kitchen, upgraded the countertops and sinks and built new wash bays with plumbing for the 4-H steers and sheep. Extension worked with the Blackfeet Tribe and Blackfeet Conservation District to create a memorandum of agreement with the Bureau of Indian Affairs, set up a budget and hired a project manager to oversee $330,000 funding to complete a Blackfeet Agriculture Resource Management Plan. The completed plan will include tribal policy that protects natural resources and helps producers thrive. Extension also coordinated a brainstorming and goal session between the Business Council and USDA Rural Development staff. Fort Belknap Extension won a First Nations Food Sovereignty Grant to provide education and support to build and utilize high tunnels and root cellars that extended the growing season for lettuce, spinach, radishes and beets. They also received funding and established chicken flocks during the spring. Fifteen more apple trees were planted in the Extension Experimental Garden at Lodgepole and more than 1000 pounds of vegetables were distributed to elders, families and programs.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development

704	Nutrition and Hunger in the Population
803	Sociological and Technological Change Affecting Individuals, Families, and Communities
805	Community Institutions, Health, and Social Services
902	Administration of Projects and Programs

V(H). Planned Program (External Factors)

External factors which affected outcomes

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

Brief Explanation

Outcomes are affected by significant natural or other emergency/disasters. As federal funding becomes less secure, local communities, out of necessity, must set priorities and Extension has a role in identifying and developing resources (financial and human) to be most effective.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

MSU Extension Community Development programs have effectively impacted each community in Montana. From expanding Community Foundation opportunities, to creating sustainable food systems in food deserts, to planning and preparing for emergencies, to educating community officials and board members, MSU Extension is actively working in communities throughout Montana to improve their vitality and quality of life of residents.

Key Items of Evaluation

• Secured $88,917 and completed the first two routes of a walking trail in Montana's least healthy county.
• Led the development of the Boulder Transition Advisory Committee which created a master plan for community sustainability after the town's largest employer closed.
• Provided leadership for the Stillwater County Library and Community Center Steering Committee that raised $40,000 (in 2016 alone), completed a conceptual design and hired a campaign consultant.
• Successfully won funding of $112,000 in grants to upgrade Chief Joseph Park playground and completed the first two phases.
• Raised $3,000 toward Community Foundation endowment in Liberty County; completed leadership trainings with 20 different volunteer governing and advisory boards.
• After years of fundraising, completed construction and opened a new Livestock Facility at Rosebud County Fairgrounds.
• Hosted 103 clerks and treasurers and 53 elected officials at the 2016 Municipal

Institute (overall rated 4.49/5). "The rules local governments have to abide by are far more grueling than a private business. The Local Government Center (LGC) keeps, not only clerks, but mayors and councils informed." Conrad Finance Officer

- LGC distributed 7 publications and managed 3 listservs reaching more than 7100 with timely information to assist with the regular operation of governments and boards.
- Two communities practiced Operation Rolling Cow exercises to prepare for accidents that occur during livestock transportation. The communities personalized plans to go with a general response outline that was created statewide by building a resource list of departments to call, people to help with veterinary care, portable fencing, and short-term loans of equipment/pasture, etc. This will improve the safety of livestock and first responders during future accidents.
- Charging Home Stampeders Fair volunteers raised $6,400 and built an addition to the existing 4-H kitchen, upgraded the countertops and sinks and built new wash bays with plumbing for the 4-H steers and sheep.
- Extension worked with the Blackfeet Tribe and Blackfeet Conservation District to create an MOU with the BIA, set up a budget and hired a project manager to oversee $330,000 funding to complete a Blackfeet Agriculture Resource Management Plan.
- Fort Belknap Reservation won a First Nations Food Sovereignty Grant which provided education, support and supplies to build and utilize high tunnels and root cellars to extend the growing season; as well as funding that established chicken flocks around the gardens.
- Planted 15 more apple trees in the Extension Experimental Garden at Lodgepole and provided more than 1000 pounds of fruit and vegetables from the garden for free to families and elders.
- Fort Peck Tribal Extension Garden invited kindergartners to grow 250 pumpkins. They harvested the pumpkins and used them to teach lessons in math class and more. They also performed soil and water testing and shared with the community how to make amendments.
- Northern Cheyenne Reservation distributed 600 pounds of free Montana Certified Seed potatoes. 120 students learned to maintain and harvest lettuce, tomatoes, potatoes, and more.

VI. National Outcomes and Indicators

1. NIFA Selected Outcomes and Indicators

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