

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

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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 2017 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 science, outreach, education and innovation in Montana. Leading the state in cutting-edge research and delivering timely applied science and information to stakeholders continues to serve the mission of the university.

COA/MAES and Extension have always maintained a close relationship, and though operations are officially separate, this 2017 Annual Report of accomplishments is completed as a joint venture. The opportunity to enhance this partnership and elevate agriculture, as well as youth development, family and consumer sciences and community development in Montana is valued and represents a clear commitment to the heritage of the state's agricultural roots.

This year, MSU is celebrating its 125th anniversary, providing myriad events and publications to reflect on the dramatic and important impacts of Montana's oldest land-grant institution. COA/MAES and Extension 2017 accomplishments and results represent modern day achievements of 125 years together of honoring the legacy and commitment of information to the people within the land-grant tradition in Montana.

Previous to this report submission, the USDA announced MSU was selected as the region's new host institution of the Western Sustainable Agricultural Research and Education, the country's foremost, producer-led research and education grant program for sustainable agriculture. The notification of the Western SARE program award greatly complements MSU's mission to advance agriculture in Montana in conjunction with competitive grant funding across COA, MAES and Extension. Hosting the Western SARE program for the next five years (2018-2023) is an opportunity for MSU to further participate in discussions regarding what the future of sustainable agriculture in the western United States may look like. Certainly, the expertise of COA/MAES and Extension, in addition to our statewide network of producers, played a competitive and crucial role in the Western SARE award to MSU.

MSU Extension has always had a ground-up structure with agents living and working across the state to ensure deep engagement with producers, families, businesses and communities. Many projects are born directly from the challenges and desires of the state's people. Often, they have tremendous impact locally, though from a quantitative viewpoint, the impacts may not seem large on a federal level. For instance, the creation of eight FTE professional jobs in a community of 400 people has a ripple effect far beyond eight new jobs in a market of thousands. For management and leadership purposes, the state is divided into three regions, East, Central and West, with department heads leading each region. Extension leverages Smith-Lever dollars with county contributions to support the salary and operations for Montana's 92 County and Reservation Extension Agents. State dollars, grant and other funding covers the expenses for the 32 campus-based specialists who translate applied research to deliver impactful programs to Montana's diverse demographics.

Smith-Lever, Hatch Act, State of Montana and county and local 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. 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.

Additionally, Extension, COA and MAES hired four 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 College of Agriculture welcomed a decade of enrollment growth in the fall of 2017. The larger university also enrolled a record number of students fall semester and celebrated enrollment records in 13 out of the last 15 years.

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.

Notably, there were sizeable natural resource challenges facing Montana agricultural industry this year. Some of these included severe drought and wildfire, coupled by low commodity markets in a warming climate. Montana's severe wildfire season during the summer of 2017 burned more than one million acres in 1,687 wildfires. An estimated 438,000 acres were burned in 21 large, active fires. According to the USDA and Montana Department of Agriculture, the cost of fighting the fires reached above \$284 million; an estimated \$53 million of that came directly from the state budget, and the rest from federal monies. Prior to, during and following the fires, MSU Extension agents and specialists provided local leadership, organization and structure to help limit negative impacts for producers, families and communities.

Difficult years such as 2017 highlight the necessity for land-grant institutions to deliver timely, meaningful research and outreach programs that support and sustain the state's economic drivers related to production agriculture and natural resources.

The USDA NASS Montana 2017 Agricultural Statistics provides a summary of the states' agricultural analysis:

- 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 were 27,500 farms and ranches in the state averaging 2,179 acres.
- Montana ranked second in the U.S. in acres devoted to farms and ranches.
- Montana produced the most pulse crops (dry peas and lentils) in the nation and was the third-highest wheat producer in the nation.
- The 2016 market value of crop production increased to \$2 billion, an increase of \$153.4 million or eight percent above 2015.
- The value of livestock decreased in 2016 to \$1.6 billion, down \$238.2 million from 2015.
- Total cash receipts (excluding government payments) for crops and livestock totaled \$3,672,844; crops totaled \$2,041,450 and livestock totaled \$1,631,394.
- Agriculture demonstrated a 4.9 percent decrease, down \$224 million from 2015.
- Montana hosted 13 foreign trade delegations and 60 visitors from seven nations interested in purchasing Montana exports (particularly grains).
- Montana wheat production represented 10.3% of the U.S. total and cattle and calves represented 2.8% of the U.S. total.

Tribal Partnerships in 2017

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; Aaniiih 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'Oreille, Kootenai of the Flathead Nation) 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, four of the reservations also partner with MSU Extension through the Federally Recognized Tribal Extension Program (FRTEP). The Blackfeet, Flathead, Fort Belknap and Fort Peck reservations all have Extension agents who live and work in the community and perform duties much like county agents. In addition, the Northern Cheyenne reservation has an externally funded Extension office.

During September of 2017, MSU Extension FRTEP agents hosted the National FRTEP Professional Development Conference in Polson, MT. Sixty-two professionals from 16 states and at least 22 reservations, and from USDA/NIFA attended. The agenda included several breakout sessions on agriculture and 4-H youth development, FRTEP updates, instruction on program evaluation and using the logic model, as well as a tour through the Flathead and Blackfeet Reservations. The group visited the Salish-Kootenai College campus for a bison dinner.

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 education 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, horticulture, pasture restoration, environmental stewardship, sustainable agricultural practices, resource and risk management, pesticide certification, 4-H youth development, healthy living 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 2016, 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.

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 natural resource extraction communities has increased the number of migratory and transient workers in some areas.

Program Areas

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 like public speaking, and good citizenship, 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 2017, 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
- Disseminate 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.

2017 accomplishments in promoting and maintaining animal health have 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 research 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. Via meetings, one-on-one discussions and interactive technologies, COA/MAES and Extension helped to ensure 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.

Extension specialists and agents in counties and reservations statewide provided ration analysis, water and soil testing and farm management analysis to assist individual ranchers, as well as communities, in improving profitability. They visited rangeland to advise on topics ranging from weeds to wildlife management and fire mitigation. Their advice was individualized and specific, taking data from devices such as GPS and monitoring systems and making it personal and practical. Youth learned animal quality assurance through 4-H and FFA projects. Extension agents also provided services to ranchers related to sheep and wool production and information and knowledge related to raising chickens and horses, particularly on smaller acreages.

Intense drought in numerous Montana counties throughout the summer of 2017 increased the importance of herd management decisions, testing nitrate and sulfates, and making feed and watering adjustments as appropriate. As an example, in Valley County, located in Northeastern Montana, forage quality testing and analysis saved producers over \$650,000 in lost revenue due to potential abortions from toxic feed. Similarly, in McCone County, 170 forage nitrate tests were conducted: 90% hay tested positive for nitrates with 30% requiring special management. Fifteen tons of high-nitrate toxic hay was burned to prevent livestock poisoning. Agents also assisted producers with effective practices for early weaning and culling cows to reduce herds. This guidance helped ranchers make educated decisions that increased profitability during a very difficult year with especially tight margins.

Finally, the University and several statewide producers together garnered competitive funding for the MSU

College of Agriculture's first Endowed Chair in Animal Science and Beef Physiology, now in its second year of existence. The chair is charged with leading a research profile of a lab, graduate and undergraduate students, and an advisory council, who will conduct meaningful and timely research that mirrors, enhances and sustains Montana's beef industry.

2. PLANT AND SOIL SCIENCES

2017 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 (particularly within a changing climate that leads to a longer growing season in warmer temperatures). 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.

In 2015, the university 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 Warhorse 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. 2017 planted acreage data was not available.

During the growing season, calls to MSU Extension offices are often between 50 and 90 percent horticulture related. Extension administers the Master Gardener program statewide and also provides regular programming and one-on-one assistance to clientele including small acreage landowners, urban home owners, renters, non-profit and business managers. Agents provide assistance on everything from planning shelterbelts to community gardens to turfgrasses, flower beds and herb gardens.

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 2017. 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.

Faculty have worked together to create a comprehensive website with nine online tools to help producers with decisions including appropriate insurance, whether on-farm oilseed and biodiesel production makes sense for an operation, comparison of current and historical commodity prices, calculating equitable pasture lease rates and more.

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 2017, 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.

MSU Extension's IPM Programs including the Schutter Diagnostic Laboratory provide training and outreach in detecting new diseases and protecting crop exports destined for international trade. Detecting seedborne diseases in pulse crops including peas, dry beans, chickpeas and lentils is a priority. MSU's Regional Pulse and Diagnostic Laboratory tests pulse crop seeds for pathogens and provides tests to ensure seed health and safety. The Lab is supported by APHIS-PPQ Farm Bill Section 10007, the U.S. Dry Pea and Lentil Council, the Montana Department of Agriculture's Specialty Crop Block Grant and others.

5. ENERGY & NATURAL RESOURCES

Across Montana in 2017, energy and natural resource studies again became increasingly necessary 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 impacted by rapid environmental change and natural resource and energy development. 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 2017 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.

MSU Extension's financial education programs 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. MSU Extension's family economics specialist, Marsha Goetting, earned the 2017 Western Region Excellence in Extension Award from Cooperative Extension, the U.S. Department of Agriculture's (USDA) National Institute of Food and Agriculture (NIFA), and the Association of Public and Land-grant Universities (APLU).

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.

Summary

While the program overview and highlights in this annual report reflect just a portion of the many accomplishments during 2017, 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 do 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 increasingly diverse audience. On behalf of Montana State University, we are pleased to present the 2017 Annual Report.

Total Actual Amount of professional FTEs/SYs for this State

Year: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	174.0	{No Data Entered}	268.0	{No Data Entered}
Actual	124.0	0.0	296.5	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 requires county and reservation agents and specialists to complete Engagement Plans (EP) that include a community needs assessment, stakeholder input, required inputs and planned outputs, as well as a plan for evaluation and data collection. Annually, these professionals report against their EPs. The Engagement Results include direct and indirect contacts, actual evaluation process used and actual measured outcomes, impact statements and a summary that includes the problem addressed, the action taken and the results or impacts of the work. These EPs and results are evaluated by county supervisors as well as Extension administration and used to validate and support the importance of the work locally, regionally, statewide and nationally. Internal editors carefully read each section for content, grammar and overall quality review.

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. Representatives meet 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 on 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. In addition, Extension is partnering in research to expand resources for youth through offering the Youth Aware of Mental Health training across the state. Extension is in the position to begin conversations around mental health and to start community capacity building on the issue in communities 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.

In addition, Extension and MAES/COA address concerns of Montana stakeholders in a wide range of issues much like 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
{No Data Entered}	{No Data Entered}	{No Data Entered}	{No Data Entered}

2. Totaled Actual dollars from Planned Programs Inputs				
	Extension		Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	1276091	0	2852892	0
Actual Matching	0	0	15456494	0
Actual All Other	1311835	0	11078297	0
Total Actual Expended	2587926	0	29387683	0

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

V. Planned Program Table of Content

S. No.	PROGRAM NAME
1	Animal Sciences
2	Plant and Soil Sciences
3	Farm, Ranch and Business Management
4	Integrated Pest Management
5	Energy and Natural Resources
6	Youth and Family Development
7	Healthy Living, Nutrition and Food Safety
8	Community Development

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%		10%	
301	Reproductive Performance of Animals	5%		10%	
302	Nutrient Utilization in Animals	5%		5%	
303	Genetic Improvement of Animals	0%		5%	
305	Animal Physiological Processes	0%		10%	
306	Environmental Stress in Animals	5%		5%	
307	Animal Management Systems	5%		5%	
308	Improved Animal Products (Before Harvest)	5%		5%	
311	Animal Diseases	10%		10%	
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%		0%	
722	Zoonotic Diseases and Parasites Affecting Humans	0%		10%	
902	Administration of Projects and Programs	0%		5%	
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: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	3.0	0.0	71.6	0.0
Actual Paid	4.3	0.0	62.0	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
117998	0	664924	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	4023930	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
23967	0	1963022	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

2. Brief description of the target audience

- Livestock producers
- Montana Stockgrowers Association
- Montana Farm Bureau
- Large animal veterinarians (rural)
- 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
- Tribal land managers
-

3. How was eXtension used?

eXtension was used to ask and answer questions and resources were contributed to Community of Practices including: Livestock and Poultry Environmental Learning Center and the Niche Meat Processors Assistance Network.

V(E). Planned Program (Outputs)

1. Standard output measures

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	7177	31558	437	4253

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

Patent Applications Submitted

Year: 2017

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	37	40	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2017	40

Output #2

Output Measure

- Number of publications on infectious disease and vaccines research

Year	Actual
2017	27

Output #3

Output Measure

- Number of presentations on infectious disease research

Year	Actual
2017	200

Output #4

Output Measure

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

Year	Actual
2017	700

Output #5

Output Measure

- Number of producers attending beef cattle workshops and clinics

Year	Actual
2017	1000

Output #6

Output Measure

- Number of Native American Youth receiving Junior Ag Loans
Not reporting on this Output for this Annual Report

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	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	Investigate economically important traits in livestock genetic improvement

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
2017	0

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 2017 Montana Agriculture Statistics report by the USDA indicates that Montana's cattle and calves industry brought in \$1.44 billion and cow milk another \$41 million in gross income in 2016. 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 and a lack of understanding of the science behind grazing rotations.

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. Several counties are piloting advanced nitrate testing, while most offer the Nitrate Quick Test.

Results

-Evaluations for beef cattle programming quality (24 programs statewide) exceeded 4.6/5 scale and 87% (1200 participants) who reported said they would utilize newly acquired knowledge.
-Due to especially volatile markets in 2017, correctly pricing hay was complicated. One producer indicated that his local agent helped him capture 22% more value for his crop than expected.

- Intense drought in Custer County led to the local Extension office offering water sulfate analysis. Over 50 samples were submitted and 18 of them were determined to be very high risk. Using Extension recommendations, prevented livestock death.
- In Stillwater county, eight producers reported that testing and analysis from Extension prevented them from feeding high nitrate feed that may have resulted in abortions or death of cattle and sheep. One producer said, "You saved me from getting in a wreck. Even if I only prevented one death, that's a lot for me."
- A southwest Montana rancher reported that using Extension to help him balance rations and adjust for antagonists saved him \$45/head. If every area rancher (43,000 cattle) had similar results, nearly \$2 million savings in inputs would be realized.

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
307	Animal Management Systems
308	Improved Animal Products (Before Harvest)
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection
603	Market Economics

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
2017	0

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 225,000 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 over a century. 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's sheep specialist left the university during the year, reducing the statewide impact in 2017. To combat a shortage in the wool industry, Extension hosts an annual, hands-on sheep shearing school. Extension also helps manage and facilitate 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.
- Per USDA-NASS, 2016, marketing of wool clips throughout Montana wool pools has contributed to the highest valued wool clip in the nation.
- Front Range Wool Pool: 35 producers delivered 31,653 pounds of wool, classed into 7 lines. More than \$7,600 in transportation costs was saved as a result; and conservatively, the economy of scale realized by having a larger lot increased the value by more than 10% or \$5634. After fees, members income increased by 22%.
- Montana's sheep specialist left mid-year, prior to reporting, thus reducing the available data.

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of Animals
302	Nutrient Utilization in Animals
307	Animal Management Systems
315	Animal Welfare/Well-Being and Protection
603	Market Economics
604	Marketing and Distribution Practices
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
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana's production livestock economy exceeds \$2 billion annually from Montana's 27,000 farms and ranches. Infectious diseases cause considerable loss for livestock producers by reducing production of animal units. Reduced sales are also caused by food safety concerns, due to infectious diseases of cattle, bison and sheep. MSU's Microbiology and Immunology Department is the only research unit in Montana focused on animal health related to diseases affecting livestock and wildlife, as well as zoonotic diseases.

What has been done

The short and long term projects include the development of new drugs, vaccines and diagnostic tools for fighting infectious diseases of livestock, humans, and wildlife. This past fiscal year, project initiation included support for three new projects including, 1. Molecular pathogenesis of West Nile Virus, 2.) Genome editing through the use of CRISPER technology, and 3.) Mucousal immunology in pigs. Each new project has direct implications livestock infection and disease resistance.

Results

A project on the pathogenesis of horse pathogen streptococcus equi identified new virulence factors and protective antigens for the development of a new strangles vaccine against the S. equi infection. Results were published on the restriction that limits the number of alphaherpes virions infection neurons of the West Nile Virus. Significant progress was made in the use on innate immune system adjuvants as countermeasures against salmonellosis in calves; including published research results on testing the effectiveness of Acai PS in enhancing innate resistance against bacterial infection.

4. Associated Knowledge Areas

KA Code	Knowledge Area
303	Genetic Improvement of Animals
305	Animal Physiological Processes
307	Animal Management Systems
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
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Factors affecting nutrition, health and performance of livestock animals overlap and collectively underpin the economic performance of Montana's \$2 billion livestock industry. Each of these factors are significantly impacted by microbes that cause a variety of infectious diseases in livestock. Use of antibiotics to treat many of these diseases are becoming more problematic because of the development of resistance and the negative public views associated with their use. Researchers at Montana State University are discovering new methods of developing vaccines for some of Montana's most popular animal diseases that are safe and inexpensive approaches to enhance innate immunity in livestock.

What has been done

Metabolomic data was obtained and is currently being analyzed. A microbial taxa has been identified as of great interest, having strong correlative relationships to animal health and productivity and has produced additional grant funding to pursue research. Synthetic TLR4 agonists activated bovine gamma/delta T cells in a similar fashion as Acai PS. Faculty are testing

the effects on inducing specific cytokine production in bovine cells. Preliminary in vivo experiments were done in which the TLR4 agonists in either water- or lipid- based carrier were given to the calves 24 hours prior to oral infection with Salmonella Typhimurium, as a basis for future experiments. Effects of immune modulators and their effectiveness were tested. Innate immune responses against the pulmonary pathogen Coxiella burnetii were tested.

Results

Data is being analyzed and several manuscripts describe longitudinally-collected microbiome and metabolome samples and data of cattle and sheep from prior to birth through up to one year of age. Results of the TLR4 pretreatment series suggests that synthetic agonists might be used in prophylactic fashion to minimize the impact of a scours outbreak in cow/calf operations. Work was continued on Coexilla burnetii and included new studies on Brucella abortus, focused on studies of host innate immune responses. Data was analyzed on collected microbiome and metabiome samples and data of cattle and sheep from prior to birth through up to one year of age. A forthcoming metagenomic anaylses is planned. The composition of cattle and sheep vaginal microbiota was determined, as was their co-variance with reproductive performance. Routes of transmission of early colonizing microbiota and their indicators/correlation with immune development were discovered and results were published.

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
311	Animal Diseases
312	External Parasites and Pests of Animals
315	Animal Welfare/Well-Being and Protection
722	Zoonotic Diseases and Parasites Affecting Humans
902	Administration of Projects and Programs
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
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The health of neonatal animals is the most significant contributor to the economic performance of livestock operations in Montana's cornerstone livestock industry, a \$2 billion annual economic sector. Neonatal illnesses reduce the profit margins through costs associated with treatment, animal losses, or reduced weaning weights and long term affects on animal performance and product quality. Enhancing feed efficiency and feed utilization in beef production systems at the neonatal state of life in livestock has the capacity to thwart many threats of animal health in sheep and cow/calf productions at many stages. MSU faculty provide an increased understanding and tools for the selection of more feed efficient nutrients and performance of Montana livestock.

What has been done

A study was evaluated on the biological sources of variation in efficiency of feed utilization. A study was completed evaluating individual animal variation in extreme high and extreme low RFI growing lambs. A study aiming to evaluate the anabolic activity of progesterone in increasing feed utilization efficiency in mature ewes has been completed. Physiological biomarkers and genetic markers for feed efficiency were identified. A publication evaluating predictive power of blood metabolites measured by NMR on predication of phenotypic variation in RFI in feedlot cattle led to a current collaboration with Texas A & M to confirm previous results with additional resolution.

Results

Impacts of copper and zinc supplementation on trace mineral status and growth in bull calves was completed. Impacts of trace mineral source on mature bull reproductive development and spermatozoa parameters were gathered. A sheep nutrient metabolism study determined that sugar beets did not have deleterious effects on sheep nutrient metabolism. A sugar beet ensiling project determined ensiling ability and quality of sugar beets for potential storage options for livestock producers. Several papers relating to the measurement and improvement of beef and sheep quality, safety and value by assessing impacts of increased nutrition in feed utilization were published.

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
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

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana's livestock industry is a cornerstone economic sector of Montana's economy, regularly exceeding \$2 billion annually. The top livestock species produced in Montana are beef and sheep, totaling about 5% of the nation's production of these species. The largest challenges in maintaining a healthy and viable livestock industry includes the value of post-harvest products, quality of meat and milk and fiber products. MSU researchers work in each of these areas so that Montana ranchers can have the most up-to-date information to maximize profit and make sound production decisions.

What has been done

Basic and applied infectious disease research: reported in two previous outcome measures. Fifteen steers were finished to the designated endpoints of standard, select and choice quality grades. They were harvested at Pioneer Meats in Big Timber, MT, and samples of muscle and adipose tissue were collected and flash frozen for RNAseq analysis. Carcass temperature and pH decline data was collected. Samples for tenderness and protein degradation were collected. An analysis is ongoing. Forty yearling lambs were harvested as well. Carcass data and cut out data were collected and samples were to sent to Texas A&M for flavor analysis on a collaborative research analysis.

Results

Several analyses are ongoing and many include PhD and Master's level thesis and faculty publications. Differences in the expression of transcription factors as the animal approaches the end of the growth curve, when compared to the measurements of tenderness, were analyzed to see if there is a specific set of biochemical processes that occurs to impact tenderness. Measurable objectives were made in the identification of transcription factors that are activated

during the finishing of beef cattle. Breed, harvest age and diet parameters were collected for possible influence on the flavor profile and consumer acceptance of meat from lambs.

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)
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection
903	Communication, Education, and Information Delivery

Outcome #7

1. Outcome Measures

Investigate economically important traits in livestock genetic improvement

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Livestock is a major driver in Montana's agricultural economic production, with more than two billion dollars annually generated. The largest component of the Montana livestock industry is beef cattle production. Beef cattle production is faced with the challenge of producing a larger percentage of high-quality animal protein, while faced with less land, feed resources and less available water. Limited natural resources, coupled with demand in production necessitates greater genomic information into production and management decisions.

What has been done

MSU acquired a genetically pure-bred Red Angus cattle herd to determine the underlying physiological mechanisms that are applicable to economically important traits in the bovine,

including; maternal efficiency, carcass and meat quality and inbreeding depression. A long-term breeding program was established that will result in data on the genetic basis of economically relevant traits by examining pedigree and genomic inbreeding to research potential variation in carcass and meat quality.

Results

A long-term breeding program was established with 46 purebred Red Angus cattle. The breeding program will result data on the impacts of maternal selection on productive efficiency, longevity and the genetic correlations between maternal traits and other economically important traits. Fifteen steers were finished to the designated endpoints of standard, select and choice quality grades. They were harvested and samples of muscles and adipose tissue were collected and flash frozen for RNAseq analysis; an analysis that is ongoing and providing research for an MS student thesis. The negative impact of inbreeding depression on production and reproductive parameters was quantified and is ongoing. A paper will be submitted for publication along with a conference presentation.

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of 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
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 equipment and personnel in modest budgets)

Brief Explanation

One of MSU Extension's two Beef Cattle Specialists left the university at the end of 2017, prior to completing reporting. She was very active throughout the year conducting workshops, connecting with producers one-on-one and interacting with shareholders and youth on topics related to livestock quality assurance, profitability and more. Impacts from her work are under-represented in this report as a result of her departure. In addition, MSU Extension's only Sheep Specialist left the university in July and also did not report any impacts. Both positions will be filled in 2018.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

- 15 steers and 40 yearlings were finished at a Montana-based meat processor at the endpoints of standard, selected and choice quality grades. Muscle and adipose tissue was collected for analysis and flavor profile (i.e., tenderness). Results will help Montana ranchers decide production management techniques to affect the final animal product for market-desired qualities.
- Factors affecting the overall nutrition, health and reproductive performance of livestock animals were examined at the microbial level. Nine Hatch research projects in microbiology and immunology used cutting edge technology to determine major sources of microbes and immune health in livestock. Results expanded scientific knowledge of the livestock gut microbiome and associated immunity to infectious diseases. Annual research results help sustain and increase the profitability and sustainability of Montana's and the U.S. livestock agricultural industries.
- Research conducted made significant advancements in the scientific community on the reduction of livestock death by infectious diseases, resulting in 32 published scientific journals. Developments included exploratory research in and scholarly discovery of new drugs, vaccines and diagnostic tools for fighting infectious diseases of livestock, humans and wildlife.
- New virulence factors and protective antigens were identified for the development of an effective strangles vaccination against *S. equi* - a popular disease for in Montana livestock horses.
- Two projects investigated the underlying physiology of economically important traits in livestock genetics. The results include genetic traits identified in maternal fertility, production efficiency, longevity, carcass and meat quality and the impacts of potentially detrimental consequences from reproductive technology such as inbreeding depression.
- Three projects identified nutritional strategies for steer and bull development and the nutritional value of alternative feed. Research results found a direct correlation to livestock health and market value in weaning weight, carcass composition and mineral supplementation to on-farm and ranch nutritional strategies.
- In McCone County, 15 tons of highly nitrate toxic hay was burned to prevent livestock poisoning, and 30% of 170 forage samples tested required special management. Agents provided education and resources to facilitate proper management and prevent loss; while efficiently using scarce resources.

Key Items of Evaluation

- Beef and sheep were harvested and processed at different stages of their life cycle and processed for flavor analysis. Results help Montana ranchers make on-ranch decisions when it comes to harvesting animal products for the most economic value.
- Improvements to vaccines and antibiotic resistance in livestock diseases were made. Hatch project research published results in peer-reviewed journals on the developments of effective and inexpensive therapies to mitigate the impact of animal diseases.
- Developments included exploratory research in and scholarly discovery of new drugs, vaccines and diagnostic tools for fighting infectious diseases of livestock, humans and wildlife. Exploratory research was conducted on infectious diseases of animals and their management in Montana.
- New disease fighting agents were identified in fighting a popular infectious disease in

livestock horses; *Streptococcus equi*.

- Scientific knowledge and advancements were made in many zoonotic diseases using advanced technology. Two projects focused on safe, inexpensive approaches to enhance innate immunity in calves, increasing the animals' resistance to infection.
- The underlying physiology of economically important traits in livestock genetics were identified. Researchers identified genetically-important traits in livestock for market conditions and livestock breeding operations and overall genetic improvement and herd health.
- Scientists identified increasingly important factors in the nutrition and feed utilization in Montana livestock. Research results found a direct correlation to feed utilization and nutrition intake to the neonatal health of livestock animals.
- Outreach and education related to severe drought led to increased soil, water and forage testing that prevented livestock death due to toxic feed and water. In some counties as much as 30% of forage was determined to be toxic. Extension agents offered solutions for balancing rations and managing herds to reduce impacts and increase profitability.
- Montana wool producers claimed the highest valued wool clip in the nation (USDA-NASS, 2016) due in part to uniform preparation, saving freight through economy of scale and educational opportunities offered through consolidated wool pools that are facilitated by MSU Extension.

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%		5%	
111	Conservation and Efficient Use of Water	0%		5%	
112	Watershed Protection and Management	10%		5%	
121	Management of Range Resources	10%		0%	
132	Weather and Climate	10%		10%	
141	Air Resource Protection and Management	0%		5%	
201	Plant Genome, Genetics, and Genetic Mechanisms	0%		10%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants	0%		10%	
204	Plant Product Quality and Utility (Preharvest)	10%		5%	
205	Plant Management Systems	10%		10%	
206	Basic Plant Biology	0%		10%	
502	New and Improved Food Products	0%		10%	
503	Quality Maintenance in Storing and Marketing Food Products	5%		0%	
601	Economics of Agricultural Production and Farm Management	10%		0%	
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: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	3.0	0.0	110.3	0.0

Actual Paid	5.0	0.0	149.8	0.0
Actual Volunteer	8.0	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
117546	0	1233041	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	7510527	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
122245	0	5647919	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Develop new crops and cultivars suitable to a warmer and drier climate
- Explore the ecological impact of climate change on Montana grazing areas
- Study the impact of a changing climate on insects
- Continue investigating crops and management systems that rely on less water consumption
- Meet one-on-one with producers, landowners and consumers to identify and address individual problems and solutions
 - Encourage email and phone conversations with members of the public
 - Offer classes, workshops, group discussions, demonstrations, field tours/trials, webinars
 - Share information at farmer's markets, county fairs and other community events
 - Attend and present information at professional conferences, county meetings and state conventions
 - Prepare and distribute public service announcements, newsletters, MONTGuides, Television (Montana PBS Montana Ag Live), eXtension, listservs, blogs, radio and other media
 - Create readily available and easily accessible databases for producers and researchers
 - Prepare research articles, fact sheets and news releases for scientists and statewide media
 - Host strategic planning meetings with state agricultural groups and Extension advisory groups
 - Develop systems that ensure food safety and agricultural security
 - Support FIFRA Section 18c products labeling requests
 - Release germplasm, new cultivars, and new genomics tools and techniques
 - Develop value-added, agriculturally based end-use products
 - Enhance partnerships among faculty across Montana institutions, producers, agricultural industry and other educational institutions
 - Enhance agricultural production practices to enhance product quality
 - Investigate and educate 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 elevator operators

3. How was eXtension used?

Extension faculty utilized eXtension to provide webinars and programming, communicate with producers, share fact sheets, evaluate courses and programs (Moodle), conduct interviews, create Extension documents and as a general resource for a wide range of information. Specialists use the platform to promote services and resources and also to answer "Ask an Expert" questions.

V(E). Planned Program (Outputs)

1. Standard output measures

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	27690	200000	1521	7073

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

Patent Applications Submitted

Year: 2017
 Actual: 2

Patents listed

PVP201700021 - Wheat, common, "Loma"
 PVP201700207 - Wheat, common, "Spur"

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	126	68	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2017	68

Output #2

Output Measure

- Number of producers participating in Field Days

Year	Actual
2017	1500

Output #3

Output Measure

- Number of people participating in range monitoring programs

Year	Actual
2017	2264

Output #4

Output Measure

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

Year	Actual
2017	8571

Output #5

Output Measure

- Number of foreign trade teams

Year	Actual
2017	15

Output #6

Output Measure

- Number of new wheat lines developed

Year	Actual
2017	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 incorporated 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	Increase the number of certified Master Gardeners and their impact in their communities.
7	Expand producer knowledge of pulse crops including disease, production, management, inoculants and pesticides.

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
2017	1465

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.

What has been done

Through presentations, workshops, press releases and media appearances, phone calls, emails, Monthly Weed Posts, Extension publications, and on-on-one consultations, Extension professionals educate Montanans about invasive plants so they can be partners in effectively managing Montana's range, wild lands and private property. In addition, county and reservations agents work to acquire grant funding to help combat local noxious weed expenses and challenges.

Results

- Eleven noxious weed identification and management programs earned a score of 4.68/5 (1=poor, 5=excellent) for overall quality.
- Following the Montana Noxious Weed Realtor Training course, the percent of participants who informed/directed clients to resources about noxious weeds increased from 45 to 90.
- Agents worked locally to apply for and manage grants to help combat noxious weeds. As an example, the West Boulder-Mission Creek Watersheds earned \$95,000 from the Montana Noxious Weed Trust Fund and \$29,644 from the US Forest Service. These cost-share grants offered assistance to landowners and managers to hire a licensed commercial pesticide applicator to treat noxious weeds or to purchase herbicide for private application on their land.
- In McCone County, 20 producers completed a management plan to implement early season control of Marehail in 2018.

-Following the diagnosis of Wheat Stem Mosaic Virus in Prairie County in 2016, producers used Extension advice to change the crop rotation from winter wheat to a non-host crop (peas) for the 2017 season.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
112	Watershed Protection and Management
121	Management of Range Resources
132	Weather and Climate
205	Plant Management Systems
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
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana is the nations' third largest producer of wheat. The state's wheat and barley economic sector regularly exceeds \$2 billion annually. 5.28 million acres of wheat were planted in Montana in 2016, 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. Montana wheat is sought after internationally for its market qualities and economically important traits. Continual improvement of crop varieties that thrive in a warming climate with less water and threatened natural resources is critically important to Montana's economy and its 27,000 farms and ranches. MSU researchers

produce new crop recommendations that include continual agronomic yield and product quality.

What has been done

The MSU winter wheat breeding program developed and released two new winter wheat varieties developed for yield, pest and disease resistance. The MSU spring and winter wheat breeding program developed improved cultivars adapted to Montana climatic conditions and cropping systems, that possess superior on-farm production characteristics and end-use qualities. Environmental, genetic, and management factors were investigated. Efficient screening, selection, and breeding strategies and procedures were developed to maximize efficiency and genetic progress in winter and spring wheat annual breeding programs. Wheat and barley experimental breeding lines were evaluated at seven locations across Montana through the Montana Agricultural Experiment Station statewide research centers. Various research experiments were completed including those involved with testing different varieties for usefulness in improving milling and baking qualities.

Results

A spring wheat germplasm was registered and two improved spring wheat varieties are currently undergoing seed increase. Two patents for winter wheat varieties were filed. Field trials across the state were conducted in crop and cultivar development and germplasm development. Integrated approaches in diverse cropping systems were evaluated to thwart the pressures of warming climate, increased pests and diseases and a longer growing season. Variety performance data was communicated across state field days and disseminated to wheat producers through popular press and digital mediums. The milestone for wheat breeding programs are varieties that are released and widely grown in Montana, and used by millers and bakers throughout the world to make bread and other wheat products.

4. Associated Knowledge Areas

KA Code	Knowledge Area
132	Weather and Climate
201	Plant Genome, Genetics, and Genetic Mechanisms
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
204	Plant Product Quality and Utility (Preharvest)
502	New and Improved Food Products
503	Quality Maintenance in Storing and Marketing Food Products
903	Communication, Education, and Information Delivery

Outcome #3

1. Outcome Measures

Number of new molecular techniques incorporated 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
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Agronomic yield and end product quality of cereal crops are two of the most important factors affecting Montana farmers' ability to remain competitive in global markets. Cereal grains account for \$2 billion dollars and one million acres of Montana's agricultural economy and landscape. Using molecular genetics and techniques, MSU scientists are researching molecular techniques to incorporate into breeding programs so that they can improve outcomes for Montana crop production.

What has been done

Experiments were completed in rice that demonstrated that native levels of leaf and start biosynthesis limit plant growth. 16 new alleles were identified and found to have three genome specific copies of Rht that modify Rht function different than the Rht semidwarfing alleles currently found in wheat varieties. Molecular genetics of plant light responses and reproductive development were used to identify plant growth and physiological regulation that have profound affects on the agricultural utility and productivity of crops.

Results

Experiments creating defined levels of amylose in both tetraploid (durum) and hexaploid (bread) wheat have progressed to the identification of combinations of individual starch synthase alleles that impart distinct levels of amylose. Genome editing tools were used to identify and design new strategies for enhanced genome engineering in Ag-related plant (and animal) systems. The molecular basis for resistance to multiple herbicide families was determined and analyses are ongoing. Mechanisms by which weedy plants respond to environmental and xenobiotic stresses were identified. Yield and quality traits were assessed in cultivars in relation to common hard red and soft spring wheat. The physiological basis associated with variations in yield and quality with abiotic and environmental factors were identified. Yield and quality of genetic materials were assessed in the absence of and presence of agronomically-important genes.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
201	Plant Genome, Genetics, and Genetic Mechanisms
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
503	Quality Maintenance in Storing and Marketing Food Products
903	Communication, Education, and Information Delivery

Outcome #4

1. Outcome Measures

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

Not Reporting on this Outcome Measure

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
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Wheat-based cropping systems and crop rotations impact soil moisture at both the on-farm and watershed levels. Loss of water and water quality is ultimately a loss of food production. Researchers at MSU are understanding how cropping systems management impacts water resources in order to protect overall water health and availability in agricultural ecosystems and landscapes in one of Montana's top wheat-producing counties. Researchers are using collaborative research methods to accomplish sustainable management of soil and water resources in a range of land-use contexts in Montana.

What has been done

A manuscript detailing how the convective precipitation system of the Northern Great Plains is in a transitional state between surface and atmospheric control during the early growing season, but

under atmospheric control during the late season. Sampling of baseflow in conditions in Judith Basin of the Judith River Watershed surface waters, wells, rain and soil water occurred in 2016-2017 and the results will be incorporated into three manuscripts planned for completion in early 2018.

Results

Agricultural management practices and water quality in the Judith River watershed project: During this reporting period, efforts were focused on publication of the research in peer-reviewed journals. As of Sept. 30, one paper was published and two were submitted and are currently under review. Gallatin River Watershed project: Competitive funding was awarded to the project by the USGS National Institute of Water Resources to study the hydrologic storage and potential responses to changing snowpack and seasonal rainfall across the transition from Hyalite Canyon through the Gallatin Valley from the mountain front to just above the confluence to from the Missouri River. An analysis of surface waters, groundwater and soils is currently underway.

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
903	Communication, Education, and Information Delivery

Outcome #6

1. Outcome Measures

Increase the number of certified Master Gardeners and their impact in their communities.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Calls to Extension offices during Montana's growing season are regularly 50-90 percent horticulture and integrated pest management (IPM) related. Individuals are increasingly interested in knowing the origin of the food they eat, diversifying their gardens and seeking information on holistic and natural pest management. Landscaping can increase property value, provide a comfortable place for social interaction and include the opportunity to grow food. MSU Extension horticulture staff and county agents are proactive in education and outreach, while also offering individualized solutions to specific challenges. Training Master Gardeners and including a service component for certification leverages their knowledge and allows more individuals to be reached.

What has been done

MSU Extension offered three levels of Master Gardener classes: Level 1 (16 hours of class time/20 hours volunteer commitment) includes basic and intermediate curriculum, Level 2 (16 hours of class time/30 hours volunteer commitment) includes a large emphasis on IPM and Level 3 (30 hours of class time/40 hours volunteer commitment) is a three-day intensive training. There are currently more than 2000 certified Master Gardeners in Montana. In addition, agents offered dozens of horticulture and IPM-related classes in their communities. County agents oversee the management of community gardens in numerous communities, assist with planning and maintenance of community parks and boulevards and regularly provide certified seed potatoes, along with education on not planting non-certified seed.

Results

A 2017 survey of certified Master Gardeners (n=444) found the following: Of the respondents, 83% gained moderate to considerable knowledge in reading and following instructions on pesticide labels, and 84% in using preventative measures for pest management. More than 99% said they had the ability to find research-based and unbiased horticulture information. A quarter said they had used information to correctly identify pests and were able to optimize their pest and disease management strategies; and half said they were able to select plants and trees that best fit their environment. After the training, 8% reported starting a business or a job because of knowledge gained, 25% reported improved job performance because of knowledge gained and 11% reported increased income because of knowledge gained. Seven percent had started growing food plants for the first time and 58% reported being more successful with growing food plants. In 2017, 652 Master Gardeners reported 11,797 volunteer hours, an economic value of more than \$230,000. Testimonials: Our grocery bill has decreased because of our increased ability to grow fruits and vegetables; I successfully utilized lady bugs rather than insecticide to correct an aphid problem; I can fertilize my garden without burning up my plants.

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
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems
206	Basic Plant Biology

- 502 New and Improved Food Products
- 903 Communication, Education, and Information Delivery

Outcome #7

1. Outcome Measures

Expand producer knowledge of pulse crops including disease, production, management, inoculants and pesticides.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	900

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

All county and reservation agents provide their local area with targeted programming. This outcome is shared as one example. Increasing agricultural profitability and sustainability was the top priority identified by the Chouteau County Advisory Council. The local agent partnered with MAES/COA and Extension professionals regionally to increase producers' knowledge and understanding of pulse crops to improve production practices and efficiencies and meet these goals.

What has been done

Ag education and outreach were achieved through the Golden Triangle Pulse 101 Workshop, the Golden Triangle Cropping Seminar, Agriculture Research Center Field Days and other programming. A microscope was purchased for the county Extension office for pest diagnosis and one-on-one teaching. Weekly newspaper articles were published in the River Press and Big Sandy Mountaineer and four additional articles were published through a larger regional publication, Traders Dispatch.

Results

-Of the 270 producers who attended the Pulse 101 Workshop, 63 identified specific changes they would make to their operation. These changes, including growing a pulse crop rather than winter wheat, amounted to an average increase in profitability of \$130/acre. At an average of 200 acres per farm, this resulted in a \$1,638,000 advantage for area producers.

-One producer who attended the Cropping Seminar decided to try different spring wheat varieties, expected to increase his profitability on 2000 acres by an estimated \$40,000.

-Because of the availability of a microscope in the Extension office, one producer saved \$2,000 in fungicide expenses by prompt diagnosis and verification of general fungi in chickpea. The producer had sprayed for Ascochyta blight ten days prior and was concerned the blight had returned.

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
121	Management of Range Resources
132	Weather and Climate
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems
206	Basic Plant Biology
502	New and Improved Food Products
601	Economics of Agricultural Production and Farm Management
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
- Other (High cost of fuel, fertilizer)

Brief Explanation

Montana saw one of the worst droughts in the state's history in the summer of 2017, coupled by a fire season that damaged nearly two thirds of the state's wild and agricultural land. Several sections of the state were declared as federal natural disasters and emergencies, with thousands of firefighters and hundreds of Montana National Guard members deployed. There were 21 large, active fires that had consumed over 438,000 acres (177,000 ha). By September 20, after rain and snow had significantly slowed most fire growth, the overall burned acreage in Montana was estimated at 1,295,959 acres (524,456 ha). The fire season began a month earlier than usual and months of June through August were the hottest and driest on record for Montana. On July 29, Montana had 11.87 percent of its total land listed as in exceptional drought, the largest percentage in the nation. Federal disaster assistance was requested by Governor Steve Bullock, who declared Montana under a State of Emergency and he and FEMA granted funds for the Rice Ridge Fire near Seeley Lake, Montana, Alice Creek Fire near Lincoln, Montana, West Fork Fire near Libby, Montana, Highway 200 Complex in Sanders County, Montana and

the Moose Peak Fire near Montana. Over \$280 million had been spent on firefighting by early August. A number of areas were subjected to evacuation orders, including most of the town of Seeley Lake. By September 18, 2017, rain and snow had significantly slowed most fires, except for parts of far northwestern Montana, near Libby, where the West Fork Fire required some evacuation orders to remain in effect through the season.

Historically low wheat prices plagued commodity markets for much of 2017, followed by an unprecedented drought that affected Montana and North Dakota immensely. The USDA categorized the drought conditions as an "extreme climatic episode" and the NRCS reported that the period from June to August in 2017 was the hottest and driest on record in Montana. Twelve of Montana's largest agricultural producing counties were categorized at Severe or Extreme Drought Intensities by the USDA.

Test sites and yield data may have been compromised due to drought and fire.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

- 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.
- The MSU Winter Wheat Breeding program developed two new winter wheat lines with quality and genetic improvements and applied for two patents. The program developed improved cultivars adapted to Montana's changing climate and cropping systems management. Scientists developed efficient screening, selection and breeding strategies and procedures to maximize efficiency and genetic progress.
- MSU researchers used advanced molecular biology tools to discover novel means in which plants respond to light and the nature of genetic mechanisms that regulate reproductive development. One peer-reviewed paper is currently under review from the research.
- Agronomic yield and the end product quality of cereal grains were examined by the impact of genes that influence seed development and determine seed composition and suitability for various end product applications.
- Molecular approaches were used in better understanding weed physiology, after producer complaints from a malt barley production area in Montana which was seeing herbicide resistance to wild oat populations. Evaluations of such produced a novel and valuable genetic resource that can provide important information about weed population response to intense herbicide selection from multiple herbicides, as well as informing proactive and eminently practical weed management strategies.
- Collaborative studies on field studies with the Extension Sugar Beet and Potato Pathology program continued to examine the opportunity to mitigate Rhizoctonia crown and root rot losses by judicious use of both seed- and foliar-applied fungicides.
- Progress reports were submitted to the Montana Wheat and Barley Committee, Western Sugar Cooperative Joint Research Committee as well as numerous producers meetings conducted throughout south central Montana.
- Two new wheat varieties are currently undergoing seed increase; including "Lanning" for dryland production. A new germplasm was registered for such.
- One graduate student was funded by MAES for spring wheat research.
- MSU researchers used collaborative research to accomplish sustainable management of soil and water resources in a range of land use contexts
- MSU researchers engaged with local communities and stakeholders to improve

research approaches and outcomes and they built research capability for students of soil and water science at MSU and in the state.

- Students and researchers sampled baseflow conditions on surface waters, wells, rain and soil water that occurred in 2017 and the results will be incorporated into three manuscripts planned for publication in 2018.
- MSU researchers used targeted research projects in multidisciplinary approaches to catalyze agricultural resilience by the creation of a local watershed observatory, and applying landscape and watershed level understanding to work with the Judith River Watershed. Embedded in these efforts is a goal of engaging and training students at MSU and across the state by the establishment of a shared bio-ecochemistry research lab within the MSU Department of Land Resources and Environmental Sciences. 27 students received analytical training, with four completing substantial field work required for industry jobs.
- Plant scientists studied the degree to which leaf and starch biosynthesis controls' the whole plant's growth and productivity. This project involved the training of two undergraduate students and one graduate students. Prepared manuscripts for peer-reviewed journals were compiled that present results from the research project.
- Results from investigating mycology in Montana focused on the diversity and distribution of mycorrhizal fungi that support woody plants and trees in Montana and biologically- related regions.
- A new germplasm was registered: Cultures and spore slurries of ectomycorrhizal fungi and a database of higher fungi of Montana was created in a research project that focuses on whitebark pine trees and alpine tundra plants.
- MSU researchers studied the potential application and genetic engineering of plant oils for industrial applications as a means to address the growing need for renewable sources of environmentally-friendly biofuels and biomaterials such as lubricants to replace or supplement products currently manufactured from petroleum. The project aims to develop improved oil compositions in camelina to meet the need for renewable and clean sources of industrial products.
- Researchers identified wheat genes that are specifically targeted by pathogens during colonization.
- A research enterprise dedicated to facilitate the production of antioxidant-rich berries and small fruits in the Northern Rockies is supporting opportunities to expand small-fruit production in Montana. Demand for small fruits in the state and nationwide is growing, largely due to an increased interest in healthy eating despite limited production, particularly in Montana.
- Researchers again studied sustainable cropping systems through diversified cropping strategies in the Northern Great Plains as farmers are seeking new knowledge in regard to nitrogen and water efficient crop rotations, and strategies to enhance soil productivity. Researchers contributed several presentations at several producer conferences around Montana representing 700 contact-hours and appeared on a specialized Montana PBS agricultural show that reached 400,000 households.
- New germplasm was registered, a fababean with small seed size, was resurrected and placed with a cover crop seed company based on bid price for available seed.
- A new germplasm, LIN 14-24, a fababean, is being increased because of interest in the cost-effective seed, which may serve well as a cover crop.

Key Items of Evaluation

- Wheat varieties produced by the MSU spring wheat breeding program were grown on 1 million acres in 2017.
- MSU researchers used advanced molecular biology tools to discover novel means in which plants respond to light and the nature of genetic mechanisms that regulate reproductive development.
- The MSU Winter Wheat Breeding program developed two new winter wheat lines with quality and genetic improvements and applied for two patents.
- Agronomic yield and the end product quality of cereal grains were examined by the impact of genes that influence seed development and determine seed composition and suitability for various end product applications.
- Field trials were conducted across the state in collaboration with the small grains breeding projects in the MSU Department of Plant Sciences and Plant Pathology
- Researchers continued MSU's productive variety development program and continued to publish research in peer-reviewed journals in plant breeding and genetics.
- MSU researchers advanced the understanding of agricultural systems and water quality in the broader context of landscapes and long-term landscape and ecosystem development in Montana.
- MSU researchers advanced the understanding of sustainability in agricultural and water resource management through an approach to soils research that takes a broad view of how soils function within Montana landscapes, watersheds, and local communities.
- MSU researchers supported sustainable agricultural management by studying local watersheds' water quality and water character (Gallatin and Judith Rivers).
- MSU researchers studied the role of leaf and seed starch in rice whole plant metabolism as a means of increasing cereal agronomic yield.
- MSU researchers expanded their knowledge of the role of carbon metabolism in whole growth and productivity.
- MSU researchers studied the whitebark pine tree and mycorrhizal fungi in artic-alpine habitats. The discoveries of such will produce restoration resources for various projects involving inoculation of whitebark pine seedlings (i.e. reforestation).
- Researchers examined how wheat cultivars and experimental lines of spring wheat of high protein content adapt to varying degrees of nitrogen and water. The project identifies a crop's physiological characterizations of the target cultivar and genes that can be used for the assessment of yield and quality variations of a specific environment and management.
- MSU researchers studied the potential application and genetic engineering of plant oils for industrial applications.
- MSU researchers monitored the invasiveness of plant populations along an environmental suitability gradient.
- Researchers advanced their understanding of plant diseases at the molecular level of a plant's biology to protect Montana crops.
- A research enterprise dedicated to facilitate the production of antioxidant-rich berries and small fruits in the Northern Rockies is supporting opportunities to expand small-fruit production in Montana to meet market demands.
- A database of all grasses of Montana and 55,212 images of Montana plant specimens housed at MSU became publicly accessible through a web portal of the Consortium of Pacific Northwest Herbaria.
- A phone app, "Grasses of Montana," was updated with 210 species.
- A Flickr account of 14,000 photos of plants maintained by MSU researchers saw visits that exceeded six million in the last eight years.

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%	
122	Management and Control of Forest and Range Fires	0%		5%	
307	Animal Management Systems	5%		0%	
601	Economics of Agricultural Production and Farm Management	30%		20%	
602	Business Management, Finance, and Taxation	5%		5%	
609	Economic Theory and Methods	5%		15%	
610	Domestic Policy Analysis	5%		25%	
611	Foreign Policy and Programs	0%		15%	
903	Communication, Education, and Information Delivery	40%		15%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	1.5	0.0	13.5	0.0
Actual Paid	4.2	0.0	7.9	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
93197	0	202100	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	816617	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
200477	0	168325	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

COA, MAES and Extension will work one-on-one and in groups with producers, landowners and consumers to identify and address individual and industry challenges and solutions. They will regularly answer specific questions through workshops, phone calls, email and personal consultations. Agents and specialists will also offer classes, workshops, group discussions, demonstrations, field tours/trials and more. Agents, specialists and volunteers disseminate knowledge at every available chance via community events and meetings. MSU Extension utilizes PSA's, newsletters, MontGuides, television, eXtension, listserves and other media. Additional priorities include:

- Publish peer reviewed articles contributing to the field
- 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 resources were used for planning and evaluation of programming, nationwide resources and curriculum development. Moodle was used for testing.

V(E). Planned Program (Outputs)

1. Standard output measures

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	3935	36000	1800	300

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

Year: 2017
 Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	48	30	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of producers attending Extension and MAES presentations

Year	Actual
2017	7000

Output #2

Output Measure

- Number of peer-reviewed journal articles

Year	Actual
2017	30

Output #3

Output Measure

- Number of non-credit instruction events

Year	Actual
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2017

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	Increased opportunities for producers to access agriculture-related decision-making tools.
5	Increase producer knowledge of crop insurance options.

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 Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Agricultural pest and disease problems cost producers and consumers billions of dollars annually in the U.S. alone. The role in technological innovation in addressing these issues is important, yet often overlooked for several reasons. Researchers at MSU are examining how management recommendations provided through new technologies can help producers make timely decisions about management.

What has been done

Trends, patterns and sources of agricultural productivity and growth was measured. The net benefits of public and private investments in agricultural research were estimated and the benefit of such to producers, consumers and the environment was characterized. The adoption and diffusion of new agricultural technologies assessing agronomic, economic, and institutional barriers to adoption and policies to overcome such barriers were analyzed.

Results

A case study on the adoption of genetically-engineered potato varieties was presented at the Agricultural and Applied Economics Association meeting and support from the project was used to attend several conferences and meetings. Ongoing work was presented regionally and several studies in journals were published. The publication process of the case study about the adoption of genetically-engineered potato varieties (including disease risks, productivity and the benefits from screening and certification) will continue. Statewide contacts and developments were made about the particular virus challenges the seed potato industry must address in Montana and surrounding areas.

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
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 Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Agricultural producers and agribusinesses are both physically and negatively affected by supply, demand, technology, risk and uncertainty and agricultural and regulatory policy dynamics. Agricultural economists at MSU are providing research-based, economic information regarding the impacts of changes in market and policy conditions on the production agriculture and food processing sectors in order to improve the ability of agricultural producers and agribusinesses to make more informed management decisions and to assist policy makers in crafting efficient, cost-effective legislation.

What has been done

The project's broad objectives used rigorous economic analysis and state-of-the-art econometric methods to provide research-based economic information regarding the impacts of changes in market and policy conditions on the production agriculture and food processing sectors. Market supply, demand, price, marketing infrastructure and landscape, and basis relationships related to agricultural input, commodity and processed food markets were estimated.

Results

Numerous research projects have been developed and either published, are under review or in progress that directly relate to the project goals. Research publications and studies used a combination of on-site experiments and market data to assess challenges and opportunities for altering production methods to increase economic and ecological sustainability in semi-arid regions. A book chapter, "Agriculture and Climate Change in Montana," investigated - as part of a larger study on climate change impacts in Montana and associated management decisions on how producers and consumers could be impacted. Numerous blog posts and recorded podcasts directly addressed applied, measureable issues related to wheat and livestock markets in a timely and relevant fashion. Much of this research was presented at five professional meetings. Many of these topics were incorporated into undergraduate agricultural economics courses.

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.

Not Reporting on this Outcome Measure

Outcome #4

1. Outcome Measures

Increased opportunities for producers to access agriculture-related decision-making tools.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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 have 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. Nine workshops reached 276 individuals. AgEconMT.com was created to give stakeholders up-to-date economic analysis, news and reports to make more informed decisions. The site now includes nine interactive planning tools. The site had 11,556 page views in 2017. Twenty-four workshops were offered to support beginning farmers. 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 4.42/5 (1=poor, 5=excellent). The average satisfaction score for beginning farmer classes was 4.5/5. Knowledge was increased in education of urban residents about the financial condition of the ag industry, basic business management and understanding insurance products. Tools on the AgEconMT.com site were used 4500 times to assist and inform in farm management decisions such as how much fertilizer to apply, whether to apply fungicide, track prices and to estimate basics. For individuals to obtain financing through the Farm Services Administration they must pass 12 exams. In support of producers, Extension graduates 20-30 students in the FSA Borrower program every year. Graduates are informed on key issues for Montana and agriculture and set up to be successful.

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

Outcome #5

1. Outcome Measures

Increase producer knowledge of crop insurance options.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	767

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Crop Insurance can be an important facet of risk management. However, because of lack of relevant policies and/or information, utilization of insurance by specialty crop, livestock, and American Indian Producers has been low.

What has been done

Extension economists worked with Blackfeet Reservation Extension, Chief Dull Knife College Extension, Fort Peck Reservation, Risk Management Agency and the Farm Service Agency in Bozeman to create additional platforms for serving a wider audience with interactive workshops and a web interface. Eight workshops were completed on four reservations and in Sidney with 767 participants.

Results

On a scale of 0 (no understanding) to 4 (perfect understanding), the average pre-test score was 1.39 and post test score was 2.61. The average speaker evaluation score was 4.2 on a 1-5 scale, 5 being excellent. The overall satisfaction score on a scale of 0 (unsatisfied) to 4 (extremely satisfied) was 3.2. The Extension Crop Insurance website was created as a key new tool. Participants reported benefitting from the hands-on examples in thinking through different options.

At workshops in Custer and Prairie Counties, Farm Bill Program participants used Extension tools to decide whether to enroll in the Price Loss Coverage Program (PLC), Agricultural Risk Coverage (ARC) programs or Supplemental Coverage Options. They also experimented whether they should update base acres and yields. At least one producer selected PLC and was able to increase potential payments by updating his wheat yield to about 10 bushels per acre higher than the county average yield previously used by the producer. Three producers followed up with the county agent after the training to input their farm numbers into the tool.

4. Associated Knowledge Areas

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

This program area is a new and growing Planned Program Area at COA/MAES. Nine research Hatch-projects were counted for 2017, four of which are multi-state designated. Montana saw one of the worst droughts in the state's history in the summer of 2017, coupled by a fire season that damaged nearly two thirds of the state's wild and agricultural land. Several sections of the state were declared as federal natural disasters and emergencies, with thousands of firefighters and hundreds of Montana National Guard members deployed. There were 21 large, active fires that had consumed over 438,000 acres (177,000 ha). By September 20, after rain and snow had significantly slowed most fire growth, the overall burned acreage in Montana was estimated at 1,295,959 acres (524,456 ha). The fire season began a month earlier than usual and months of June through August were the hottest and driest on record for Montana. On July 29, Montana had 11.87 percent of its total land listed as in exceptional drought, the largest percentage in the nation. Federal disaster assistance was requested by Governor Steve Bullock declared Montana under a State of Emergency and he and FEMA granted funds for the Rice Ridge Fire near Seeley Lake, Montana, Alice Creek Fire near Lincoln, Montana, West Fork Fire near Libby, Montana, Highway 200 Complex in Sanders County, Montana and the Moose Peak Fire. Over \$280 million had been spent on firefighting by early August. A number of areas were subjected to evacuation orders, including most of the town of Seeley Lake. By September 18, 2017, rain and snow had significantly slowed most fires, except for parts of far northwestern Montana, near Libby, where the West Fork Fire required some evacuation orders to remain in effect through the season. Historically low wheat prices plagued commodity markets for much of 2017, followed by an unprecedented drought that affected Montana and North Dakota immensely. The USDA categorized the drought conditions as an "extreme climatic episode" and the NRCS reported that the period from June to August in 2017 was the hottest and driest on record in Montana. Twelve of Montana's largest agricultural producing counties were categorized at Severe or Extreme Drought Intensities by the USDA.

As such, much of the research and extension support on behalf of Montana agriculture was focused on supporting producers recovering from natural disaster and educating and supporting producers through challenging farm and ranch insurance recovery programs.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

- Impacts were examined of recent fluctuations in capital and commodity markets on the performance, management and regulation of financial institutions.
- Management strategies, capital needs and policy impacting the financial performance and long-term sustainability of farms in the food and agribusiness sector were evaluated.
- Price discovery and risk management in crop output and input markets was investigated. The project examined the complex, dynamic, and risk market environment faced by agricultural commodity producers, traders and end-users. Research output informed risk management and policy decisions made by agriculture industry stakeholders by providing assessment of the impact of those decisions on output and input markets, as well as other industry stakeholder groups.
 - Papers were published on price dynamics in agricultural markets that estimated the role of financial speculators in commodity price determination.
 - Market supply, demand, price, marketing infrastructure and landscape and basis relationships related to domestic agricultural input, commodity and processed food markets were researched and published in several peer-review journals.
 - Research on understanding and improving agricultural and food marketing and policy provided insights that will aid in developing future academic research, make more informed production and commodity marketing decisions and craft cost-effective policy that minimizes social costs of a policy and those obtaining benefits.
 - Research efforts allowed the successful survival of owning families and businesses to serve as important elements in rural communities and investigated the conditions that led to a family business closure. The sources of change and disruption that impacts the family and household were identified and measured. The purpose of the research was to examine the characteristics contributing to small firm survival after Hurricane Katrina, though the study also examined the impacts of federal disaster assistance on rural, agriculturally-based communities.
 - The marketing and delivering of quality grains and bioprocess co-products sought to develop efficient operating and management systems that maintain quality, capture value, and preserve food safety in the farm-to-user supply chain.
 - Effects of crop insurance and other risk management tools were examined, upon the financial and economic viability of Montana and U.S. agricultural producers and rural financial institutions.
 - The ability of futures and forward markets to inform managerial decision-making and provide risk reduction benefits for Montana and U.S. agricultural producers were examined and resulted in a larger research project with respect to various aspects of crop insurance.

Key Items of Evaluation

- Impacts were examined of recent fluctuations in capital and commodity markets on the performance, management and regulation of financial institutions.
- The ability of futures and forward markets to inform managerial decision-making and provide risk reduction benefits for Montana and U.S. agricultural producers were examined.
- Crop insurance programs were examined to find the best cost-benefit for Montana

producers.

- Impacts were examined of recent fluctuations in capital and commodity markets on the performance, management and regulation of financial institutions.
- Papers were published on price dynamics in agricultural markets that estimated the role of financial speculators in commodity price determination.
- The marketing and delivering of quality grains and bioprocess co-products sought to develop efficient operating and management systems that maintain quality, capture value, and preserve food safety in the farm-to-user supply chain.
- Price discovery and risk management in crop output and input markets was investigated.
- A website and podcast series dedicated to the creation and curation of agricultural market analysis for Montana producers was created. There are six faculty regular contributors.

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%		10%	
212	Diseases and Nematodes Affecting Plants	10%		10%	
213	Weeds Affecting Plants	15%		10%	
214	Vertebrates, Mollusks, and Other Pests Affecting Plants	0%		10%	
215	Biological Control of Pests Affecting Plants	15%		10%	
216	Integrated Pest Management Systems	25%		10%	
314	Toxic Chemicals, Poisonous Plants, Naturally Occurring Toxins, and Other Hazards Affecting Animals	0%		5%	
601	Economics of Agricultural Production and Farm Management	5%		5%	
603	Market Economics	0%		5%	
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%		10%	
721	Insects and Other Pests Affecting Humans	0%		5%	
903	Communication, Education, and Information Delivery	25%		5%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	3.0	0.0	62.0	0.0
Actual Paid	9.4	0.0	31.9	0.0

Actual Volunteer	0.1	0.0	0.0	0.0
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2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
127685	0	318269	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1009915	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
343503	0	1247780	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Meet one-on-one with producers, landowners and consumers to identify and address individual problems and solutions
 - Encourage email and phone conversations with members of the public
 - Offer classes, workshops, group discussions, demonstrations, field tours/trials, webinars
 - Share information at farmer's markets, county fairs and other community events
 - Attend and present information at professional conferences, county meetings and state conventions
 - Prepare and distribute public service announcements, newsletters, MONTGuides, Television (Montana PBS Montana Ag Live), eXtension, listservs, social media, radio and other media
 - Create readily available and easily accessible databases for producers and researchers
 - Prepare research articles, fact sheets and news releases for scientists and statewide media
 - Host strategic planning meetings with state agricultural groups
 - Develop systems that ensure food safety and agricultural security
 - Integrate 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 integrated pest management
 - 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 primarily used for evaluation and planning tools.

V(E). Planned Program (Outputs)

1. Standard output measures

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

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

Patent Applications Submitted

Year: 2017

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	0	48	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of samples processed by Schutter Diagnostic Laboratory.

Year	Actual
2017	2554

Output #2

Output Measure

- Number of certified and re-certified pesticide applicators.

Year	Actual
2017	5500

Output #3

Output Measure

- Number of volunteers helping to trap wheat stem sawflies and other pests

Year	Actual
2017	595

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.
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 to increase knowledge and ability to manage pests and diseases affecting producers.
4	Develop seasonal management programs and applied pest and disease management research that leads to improved management practices.
5	Increase the number of producers/ranch managers who implement range monitoring activities which lead to improvement in resource management strategies.

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.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana's agricultural economy is heavily dependent upon the success of the state's wheat acreage enterprise. In 2016, total crop production in Montana netted more than \$2 billion for Montana's agriculturally-dependent economy. New pests continue to emerge and threaten the success of Montana's wheat cash crop by way of reducing farmer profitability. Researchers at MSU are continually identifying, understanding and developing treatments to ensure producers are equipped with the latest management and treatment recommendations of pest infestations.

What has been done

Researchers continue to focus on the development of earlier findings of new pest infestations and host plant resistance. Testing known candidate factors for genetic manipulation to control insects were undertaken in an effort to show feasibility. Researchers increased the implementation of semi-chemically-informed traps across the state. New sources of host plant resistance were pursued with both winter and spring wheat breeders, primarily through germplasm screenings. Research was continued on host plant resistance, insect behavior and natural enemies in addition to crop and storage economics.

Results

Researchers used pheromone lures and traps to establish capture correlations with infestation and yield that will provide growers with an opportunity to assess the potential impacts of pests at the beginning of the season, rather than at harvest. The information will be useful for planning agronomic management strategies based on data. Research was continued on trap crops and work was generated on a bio economic assessment of them. Parasitoid pheromones were identified with the goal of monitoring abundance. New forms of resistance were targeted following the evaluation of unexpectedly high genetic diversity in wheat stem sawfly populations in Montana

wheat fields.

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
2017	1803

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The Montana Private Applicator Training (PAT) Program is coordinated by MSU Extension through a Memorandum of Agreement with the Montana Department of Agriculture. The PAT Program provides certification and training to approximately 5,500 private applicators across Montana. Private Pesticide Applicator certification allows individuals and/or their employees to apply Restricted Use Pesticides (RUPs) to land they own, rent or lease for the purpose of growing an agricultural commodity. To be certified, a private applicator must show practical knowledge of pest problems and pest control practices associated with their agricultural operations; proper storage, use, handling and disposal of the pesticides and containers; and their related legal responsibility.

What has been done

During 2017, the MSU Extension Pesticide Education Specialist provided presentations over seven core subject areas (private applicator license, reading the pesticide product label, integrated pest management, pesticide safety, pesticide laws, calibration of spray equipment and pesticides in the environment) to 1,803 applicators at 56 programs. The Extension Pesticide Education Program (PEP) focused on non-target toxicity, security of pesticides, sprayer calibration and pesticide poisoning. Classes included cleaning sprayers effectively, selecting nozzles for drift, water quality and pesticide performance, fumigant poisoning, pesticides and pollinators, groundwater contamination and more.

Results

When more applicators properly clean sprayers and purchase low drift nozzles, there is a reduction in pesticide damage to adjacent crops, lower incidence of pesticide introduced into the ground and surface water, and fewer poisonings; all of which result in financial and environmental benefits. Following a subset of classes in 2017, participants rated the effectiveness of the speaker at 4.6 on a 5.0 scale, with five being very effective. Pre to post tests on cleaning pesticide equipment revealed an increase of 35% of participants being able and willing to properly clean spray equipment. In addition, 61% indicated they understood the importance of limiting off-target movement of pesticides and as a result, intended to purchase drift-reducing nozzles.

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Diseases and Nematodes 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
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

Outcome #3

1. Outcome Measures

Develop, enhance and distribute pest management programs to increase knowledge and ability to manage pests and diseases affecting producers.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana's agricultural economy is heavily dependent upon the success of the state's crop enterprise. In 2016, total crop production in Montana netted more than \$2 billion for Montana's agriculturally-dependent economy. New pests and disease continue to emerge and threaten the success of Montana's wheat cash crop by way of reducing farmer profitability. Researchers at MSU are continually identifying, understanding and developing treatments to ensure producers are equipped with the latest management and treatment recommendations of pest and disease infestations.

What has been done

The ecology of invasive species and their management was targeted in several faculty projects that determined the environmental safety of exotic candidates prior to release and evaluated natural enemy efficacy and studied the ecological and physiological basis for insect-host interactions. Projects also investigated the biology and ecology of the target weed or other invasive species with emphasis on their future management. Several faculty projects focused on the integrated weed management in dryland and irrigated cropping systems of Montana; integrated research focused on developing sustainable and cost-effective weed management strategies for statewide producers.

Results

Weed biology and ecology information and integrated strategies for management of herbicide-resistant kochia in Northern Great Plains cropping systems were developed and disseminated statewide. Weed control and herbicide efficacy was evaluated with registered and experimental herbicides in dryland and irrigated cropping systems. Field experiments were conducted

statewide to characterize the timing and pattern of emergence period. Researchers collected, redistributed and monitored populations and estimated impacts of the rush skeletonweed root moth and host specificity was tested on the Chondrilla crown moth for the biological control of skeletonweed.

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 #4

1. Outcome Measures

Develop seasonal management programs and applied pest and disease management research that leads to improved management practices.

Not Reporting on this Outcome Measure

Outcome #5

1. Outcome Measures

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 Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Invasive weeds threaten rangeland health by way of altered structure, organization and function of rangeland plant communities. In 2017, Montana agricultural producers used 4.5 million pounds of herbicide applications on nearly 3.2 million acres for weed control. This increased reliance on off-farm inputs threatens the overall economic, environmental and societal health of agricultural acreage dependent upon herbicide and pesticide use. Researchers at MSU are investigating the ecological underpinning of integrated weed management in Montana and are studying alternative range weed management to combat increasingly herbicide-resistant weed populations.

What has been done

In dual research and extension programs, researchers are privileging the evaluation of the ecological underpinning of integrated weed management and the integration of cultural practices with biological and ecological processes. Researchers characterized multiple herbicide-resistant weed populations, conducted ecological characterization of herbicide resistance in *Avena fatua*, maximized the efficacy of downy brome biocontrol, studied the ecological role of grassy weeds in mite-transmitted cereal viruses and targeted animal grazing to reduce tillage in organic dryland to enhance weed control.

Results

Methods for revegetating invasive plant-infested rangeland were developed and researchers increased their ecological understanding and integrated management of downy brome and tall buttercup. Researchers quantified the impact of planting time on the establishment of native grasses and the invasive annual grass downy brome. Researchers measured plant community response to invasive plant control and determined thresholds for natural recovery versus for active revegetation. The integration and implementation of various plant species were tested as potential methods of biocontrol for downy brome and tall buttercup. The effect of soil moisture was tested on tall buttercup's seedling emergence and growth. Outputs included four peer-reviewed journal articles, five Extension publications, and ten Extension-related activities such as presentations, workshops, monthly Weed Posts, newsletters and press releases.

4. Associated Knowledge Areas

KA Code	Knowledge Area
211	Insects, Mites, and Other Arthropods Affecting Plants
213	Weeds 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
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources
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

Montana saw one of the worst droughts in the state's history in the summer of 2017, coupled by a fire season that damaged nearly two-thirds of the state's wild and agricultural land. Several sections of the state were declared as federal natural disasters and emergencies, with thousands of firefighters and hundreds of Montana National Guard members deployed. There were 21 large, active fires that had consumed over 438,000 acres (177,000 ha). By September 20, after rain and snow had significantly slowed most fire growth, the overall burned acreage in Montana was estimated at 1,295,959 acres (524,456 ha). The fire season began a month earlier than usual and months of June through August were the hottest and driest on record for Montana. On July 29, Montana had 11.87 percent of its total land listed as in exceptional drought, the largest percentage in the nation. Federal disaster assistance was requested by Governor Steve Bullock, who declared Montana under a State of Emergency and he and FEMA granted funds for the Rice Ridge Fire near Seeley Lake, Montana, Alice Creek Fire near Lincoln, Montana, West Fork Fire near Libby, Montana, Highway 200 Complex in Sanders County, Montana and the Moose Peak Fire near Montana. Over \$280 million had been spent on firefighting by early August. A number of areas were subjected to evacuation orders, including most of the town of Seeley Lake. By September 18, 2017, rain and snow had significantly slowed most fires, except for parts of far northwestern Montana, near Libby, where the West Fork Fire required some evacuation orders to remain in effect through the season.

Historically low wheat prices plagued commodity markets for much of 2017, followed by an unprecedented drought that affected Montana and North Dakota immensely. The USDA categorized the drought conditions as an "extreme climatic episode" and the NRCS reported that the period from June to August in 2017 was the hottest and driest on record in Montana. Twelve of Montana's largest agricultural producing counties were categorized as Severe or Extreme Drought Intensities by the USDA.

As such, much of the research and extension focus for the fall of 2017 was focused on range and grassland recovery following extreme drought and fire conditions. Many drought-named field sites and yield data collection may have been compromised.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

- Teaching modules for students were created and training activities for certified crop consultants were held. Grower and professional meetings to discuss either the wheat stem sawfly or stored grain insects were held.
- Research projects resulted in additional funding from USDA-NIFA, Western SARE, state commodity groups and private industry. There were 34 invited presentations at grower and ag-industry meetings and fields days during 2017.
- 48 peer-reviewed articles were published on integrated management of pests and weeds in Montana. One faculty member, due to prolific research on herbicide-resistant kochia in Montana tied to his Hatch project, was named the National Weed Association of America's Outstanding Early Career Scientist.
- Research results were presented at 25 oral and poster presentations at regional and national weed science meetings with proceedings and abstracts.
- Graduate students were mentored on the monitoring of increased biological control via native endemic parasitoids in landscapes featuring greater crop diversity.
- Six education aids and curricula were produced on identifying and managing insect pests of stored grain and MSU hosted the Montana 2017 crop pest management school in Bozeman with 63 attendees.
- 34 Extension outreach presentations that reached 1,700 participants were conducted in stakeholder meetings and regular Extension training provided by MSU. Eight news articles were published on the integrated management of agricultural weeds in Montana.

Key Items of Evaluation

- Biological control agents of invasive weeds were provided to land managers in the western U.S., along with protocols for releasing and monitoring agents.
- Weed biocontrol agents were provided to regional and local cooperators.
- Researchers provided information on how to improve methods for revegetating invasive plant-infested rangeland by defining the best time to plant seeds of desired grasses.
- Researchers tested the effectiveness of several biocontrol methods and agents of invasive weeds colonizing Montana rangelands.
- Researchers quantified the impact of planting time on the establishment of native grasses and the invasive annual grass downy brome.
- Researchers measured plant community response to invasive plant control and determined the thresholds for natural recovery versus active revegetation.
- Researchers increased their understanding of the ecology and integrated management of downy brome and tall buttercup.
- Researchers characterized new herbicide-resistant weed populations that pose significant agronomic and economic threats to Montana.
- Researchers developed integrated pest and disease management methods with ecologically-based tactics for sustainable management.
- Researchers developed weed biology and ecology information and integrated strategies for management of herbicide-resistant kochia in Montana and the Northern Great Plains region.
- Researchers evaluated weed control and herbicide efficacy with registered and experimental herbicides in dryland and irrigated cropping systems.
- Researchers provided growers and agricultural professionals with unbiased tools and research-based information on weed management for enhanced profitability and sustainability of agricultural production systems.
- Researchers examined pulse crop tolerance and weed control with fall-applied soil

residual herbicides.

- Researchers identified glyphosate-resistant russian thistle and horseweed in Montana and Washington.
- Researchers used pyroxasulfone for downy brome control in winter wheat.
- Researchers contained exotic arthropods, nematodes and plant pathogens used for the biological control of invasive weeds of regional importance.
- Researchers removed pathogens, parasites, and other organisms from imported material.
- Researchers facilitated the importation, augmentation, study and release of biological organisms.
- Researchers conducted basic and applied research for management of the wheat stem sawfly and stored grain insects.
- Research was conducted on host plant resistance, semiochemicals, insect behavior, natural enemies, crop and storage economics.
- Potential sources of host plant resistance in barley was investigated.

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%		10%	
112	Watershed Protection and Management	5%		10%	
122	Management and Control of Forest and Range Fires	5%		5%	
123	Management and Sustainability of Forest Resources	10%		5%	
124	Urban Forestry	5%		0%	
131	Alternative Uses of Land	5%		5%	
132	Weather and Climate	5%		10%	
135	Aquatic and Terrestrial Wildlife	5%		5%	
136	Conservation of Biological Diversity	5%		5%	
141	Air Resource Protection and Management	0%		5%	
402	Engineering Systems and Equipment	5%		0%	
605	Natural Resource and Environmental Economics	5%		10%	
903	Communication, Education, and Information Delivery	35%		10%	
Total		100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	4.5	0.0	22.9	0.0
Actual Paid	3.2	0.0	40.7	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
32451	0	367168	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1799079	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
85700	0	1954226	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

COA, MAES and Extension will work one-on-one and in groups with landowners and consumers to identify and address individual and industry struggles and solutions. They will regularly answer specific questions through workshops, phone calls, email and personal consultations to address topics such as forest and rangeland stewardship and water quality.

COA, MAES and Extension will partner with local and state associations and organizations that are concerned about natural resource issues. In particular, they will engage 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 will offer classes, workshops, group discussions, demonstrations, online resources and field tours/trials. Agents, specialists and volunteers will disseminate knowledge via community events and meetings, websites and social media. MSU Extension and MAES will utilize PSA's, newsletters, MONTGuides, television, eXtension, listservs, social media, and other sources to share information.

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
- 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

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	1557	5200	0	3000

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

Year: 2017
 Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	8	21	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations

Year	Actual
2017	21

Output #2

Output Measure

- Number of people attending forest stewardship programming

Year	Actual
2017	133

Output #3

Output Measure

- Number of people attending water quality programming, including workshops and seminars to learn about watersheds and environmentally sustainable best practices.

Year	Actual
2017	760

Output #4

Output Measure

- Number of participants attending training through the Weatherization Center

Year	Actual
2017	302

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	Expand knowledge of environmental microbiology and impacts to food production, human and environmental health
10	Determine factors (abiotic/biotic) affecting honey bee colony losses
11	Improve ecological resilience, sustainable management of Rangeland systems
12	Increase ecological understanding of transport water, chemical elements and energy exchange in agricultural and forest ecosystems

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 Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

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. Four stewardship workshops were offered in 2017 with 104 participants and nine volunteers. The total acreage managed by participants was 19,299. In addition, MSU Extension Forestry teaches the Project Learning Tree (PLT) environmental education program to teachers and others who work with youth from preschool through grade 12. In 2017, 120 educators participated, 90% will use PLT in their classes within three months, reaching over 2700 students. Extension Forestry also provides outreach through news releases, listservs, social media, brochures and publications.

Results

Of stewardship workshop survey respondents, 73% planned to apply for cost-share funds to thin and reduce fire hazards. An increase from 62% to 77% planned to manage their land for specific wildlife. Plans included 711 acres of commercial harvests and 831 acres of intermediate treatments including pre-commercial thinning, planting and pruning. Following the workshop, one participant reported: We received grants from both the Bitterroot RC&D for fire hazard reduction (logging) and DNRC (weed control). Our logging is nearly complete, seeding was done just before the rain hit 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 & plant identification skills learned in class. This helped justify our weed control priority and get the grant. Also in 2017, Extension visited 29 forest owners/managers who completed the class five years ago. These reported: 90 acres of pre-commercial thinning, 825 acres of weed control implemented, 281 acres harvested and 476 acres of slash removal and other management complete. The majority continued to actively manage their forests to control weeds, provide wildlife habitat and manage their trees.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
104	Protect Soil from Harmful Effects of Natural Elements
123	Management and Sustainability of Forest Resources
131	Alternative Uses of Land
132	Weather and Climate
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 Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

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 six classes with 142 participants. The Big Sky Watershed Corp program places 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 4.2/5. All 27 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. Due to the drought across much of the state in 2017, sulfate testing was implemented in many county offices to help ranchers determine livestock suitability.

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
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.

Not Reporting on this Outcome Measure

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.

Not Reporting on this Outcome Measure

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.

Not Reporting on this Outcome Measure

Outcome #7

1. Outcome Measures

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

Not Reporting on this Outcome Measure

Outcome #8

1. Outcome Measures

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

Not Reporting on this Outcome Measure

Outcome #9

1. Outcome Measures

Expand knowledge of environmental microbiology and impacts to food production, human and environmental health

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

In the Western United States, approximately 70% of carbon sink activity is located at elevations above 750m, where 50%-85% of land is dominated by hilly or mountainous topography. Given the extensive distribution of subalpine forests, a better global understanding of how these ecosystems contribute to Carbon exchange within the atmosphere is critical, as there is little information regarding the soil microbial communities involved. Researchers at MSU are investigating the role and importance of soil methanotrophs in consuming atmospheric methane gas to better understand the role and health of alpine forests. This research vein also provides direct links to the important role of microorganisms to environmental health and function.

What has been done

Researchers characterized soil microbial community structure and diversity, with a specific interest in methane cycling. Researchers studied microbe interactions with arsenic and mercury, in environments that span from soil and aquatic environments to the human microbiome. Researchers gathered baseline data for a long-term monitoring of metal and metalloid accumulation in environments not directly affected by anthropogenic inputs but that accumulate toxins as a result of non-source point contamination.

Results

Researchers finished a long-term data analysis that assesses microbial community structure in a sub-alpine forest soil environment. Researchers began work on a two-year assessment of status and trends in bioaccumulation of mercury, a strong neurotoxin, in water, sediments, and aquatic species of depressional prairie potholes of the Fort Belknap Indian Community. A survey of mercury levels in biotic and abiotic components of wetlands will support selection of subset of pristine and impacted wetland types for more detailed characterization of hydrologic and biogeochemical to wetland species and habitat. Researchers established a baseline for comparison against future levels of mercury and evaluated changes of climate/mercury deposition on wetland ecological functions and services for a prairie ecosystem.

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
132	Weather and Climate
135	Aquatic and Terrestrial Wildlife
136	Conservation of Biological Diversity
141	Air Resource Protection and Management
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

Outcome #10

1. Outcome Measures

Determine factors (abiotic/biotic) affecting honey bee colony losses

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Honey bees are important pollinators of agricultural crops and plant species that enhance ecosystem biodiversity. High annual losses of U.S. honey bee colonies (averaging 33% since 2006), have been associated with viruses. Montana ranks second in the nation for honey production and provides more than 150,000 honey bee colonies for pollination services. However, little is known about honey bee host-virus interactions as they remain largely uncharacterized. Researchers at MSU are investigating methods to reduce honey bee colony losses caused by virus infections by advancing the epidemiologic and mechanistic understanding of the effects of viruses on honey bee health.

What has been done

Researchers continued performing honey bee host-pathogen interaction research at the colony, individual bee, and cellular levels. Experiments, sample collection, and data analysis are ongoing. The role of pathogens was investigated (viruses, mites, fungi and bacteria) in honey bee colony losses. Mechanisms of viral dsRNA triggered pathways were investigated as a means of antiviral responses in honey bees. Researchers examined RnAi as a mediated immune response potentially as a primary mechanism of honey bee antiviral defense and that many of the genes involved in these antiviral defense pathways were transcriptionally regulated.

Results

Researchers provided seven scientific presentations, mentored 13 undergraduate students, two PhD students, and three students have obtained graduate degrees in honey bee and colony loss fields. Researchers gave four presentations to bee keeping organizations, and engaged with the public five times in a range of formats including presentations and field days. Researchers published 4 articles in peer-reviewed journals and developed a university honey bee outreach site and pollinator garden, a .5 acre site that serves as a hub of for research and community stakeholder activities. Researchers obtained longitudinally collected bee samples from commercial bee keeping operations and assessed the pathogen prevalence and abundance associated with these samples.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
104	Protect Soil from Harmful Effects of Natural Elements
112	Watershed Protection and Management
123	Management and Sustainability of Forest Resources
132	Weather and Climate
135	Aquatic and Terrestrial Wildlife
136	Conservation of Biological Diversity
141	Air Resource Protection and Management
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

Outcome #11

1. Outcome Measures

Improve ecological resilience, sustainable management of Rangeland systems

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Factors such as climate change, non-native plants and emerging plant diseases affect the vegetation health of world range lands. Wild range lands produce high quality forage for livestock, biological diversity, wildlife habitat, clean water and air provide recreational, aesthetic, and societal value. An improved understanding of the effects of future climate regimes is needed to ensure range land managers are equipped with the most current knowledge to best adapt to changing environmental conditions. MSU researchers are investigating how to better understand the patterns and mechanisms of vegetation change in order to protect range land health.

What has been done

Cheatgrass invasion in the Great Basin has been identified as a function of competition for soil moisture. Knowledge was added to the spread of Cheatgrass invasion across range in the U.S. Differences in Cheatgrass were quantified in their abundance in response to differing precipitation regimes. Relationships were identified between cheatgrass abundance, disturbance, site characteristics and precipitation regime. Research focused on woody plant invasion and understory/overstory dynamics has shown that the State and Transition models are effective tools for describing vegetation dynamics in semi-arid forested systems.

Results

Four peer-reviewed journal articles were published on invasive and woody plants in range lands. Results were presented to six professional organizations relating to range management and taught to undergraduate and graduate students at MSU. Funding was initiated and received for a complementary research project to identify and quantify biotic and abiotic site characteristics including vegetation, disturbance history and climate that are found in cheatgrass-invaded locations in Montana foothills. Conifer expansion was studied and several stakeholder meetings were organized to discuss possible grant funding for field treatments and applied research. Researchers provided ecologically-based information to range land and natural resource

managers that assisted in developing appropriate management techniques to ensure continued and sustained production of modern range lands.

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
131	Alternative Uses of Land
132	Weather and Climate
135	Aquatic and Terrestrial Wildlife
136	Conservation of Biological Diversity
141	Air Resource Protection and Management
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

Outcome #12

1. Outcome Measures

Increase ecological understanding of transport water, chemical elements and energy exchange in agricultural and forest ecosystems

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Additional knowledge is needed to improve the understanding of transport water from the terrestrial surface to the atmosphere, given that water responds to global changes and environmental ways. In a warming climate, additional understanding of surface-atmosphere

transport of water and heat may have the ability to model regional climate, which can determine the best forest and agricultural management strategies across the Northern Great Plains.

What has been done

Canopy conductance to carbon uptake and water loss was found to exhibit behavior consistent with the optimality theory. A competitive grant is planned to apply through NASA to validate land surface evapotranspiration and transpiration estimates from the forthcoming ECOSTRESS mission, using multiple approaches for estimating T and E using eddy covariance observations. A new analysis of denitrification across multiple tropical forests and how they might constrain plant growth was published.

Results

Projects contributed directly to the training and professional development of two graduate students and three undergraduate students. Six peer reviewed journal articles were published. Projects achieved several high impact results that help scientists and society understand the biological controls and physical constraints to coupled N and C dynamics and in terrestrial ecosystems. Two papers were published in press that address land use nitrogen losses and carbon capture and sequestration in the Upper Missouri Basin. Considerable progress was made in isotopic analysis of over 130 years of herbarium records for common grassland species in Montana.

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
131	Alternative Uses of Land
132	Weather and Climate
135	Aquatic and Terrestrial Wildlife
136	Conservation of Biological Diversity
141	Air Resource Protection and Management
605	Natural Resource and Environmental Economics
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

MSU Extension no longer has a Housing and Environmental Specialist or a Wildlife Specialist. As a result, work in these areas is being done on a smaller level. Many agents, for instance, offer MontGuides and other Extension publications to assist walk-in customers and others with questions in these areas, but it is not a statewide focus.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

- Researchers finished a long-term data analysis that assesses microbial community structure in a sub-alpine forest soil environment. Researchers began work on a two-year assessment of status and trends in bioaccumulation of mercury, a strong neurotoxin, in water, sediments, and aquatic species of depressional prairie potholes of the Fort Belknap Indian Community. A survey of mercury levels in biotic and abiotic components of wetlands will support selection of subset of pristine and impacted wetland types for more detailed characterization of hydrologic and biogeochemical to wetland species and habitat. Researchers established a baseline for comparison against future levels of mercury and evaluated changes of climate/mercury deposition on wetland ecological functions and services for a prairie ecosystem.

- Researchers provided seven scientific presentations, mentored 13 undergraduate students, two PhD students, and three students have obtained graduate degrees in honey bee and colony loss fields. Researchers gave four presentations to bee keeping organizations, and engaged with the public five times in a range of formats including presentations and field days. Researchers published 4 articles in peer-reviewed journals and developed a university honey bee outreach site and pollinator garden, a .5 acre site that serves as a hub of for research and community stakeholder activities. Researchers obtained longitudinally collected bee samples from commercial bee keeping operations and assessed the pathogen prevalence and abundance associated with these samples.

- Four peer-reviewed journal articles were published on invasive and woody plants in range lands. Results were presented to six professional organizations relating to range management and taught to undergraduate and graduate students at MSU. Funding was initiated and received for a complementary research project to identify and quantify biotic and abiotic site characteristics including vegetation, disturbance history and climate that are found in cheatgrass-invaded locations in Montana foothills. Conifer expansion was studied and organized several stakeholder meetings to discuss possible grant funding for

field treatments and applied research. Researches provided ecologically-based information to range land and natural resource managers that assisted in developing appropriate management techniques to ensure continued and sustained production of modern range lands.

- Projects contributed directly to the training and professional development of two graduate students and three undergraduate students. Six peer reviewed journal articles were published. Projects achieved several high impact results that help scientists and society understand the biological controls and physical constraints to coupled N and C dynamics and in terrestrial ecosystems. Two papers were published in press that address land use nitrogen losses and carbon capture and sequestration in the Upper Missouri Basin. Considerable progress was made in isotopic analysis of over 130 years of herbarium records for common grassland species in Montana.

Key Items of Evaluation

- Researchers finished a long-term data analysis that assesses microbial community structure in a sub-alpine forest soil environment
 - Researchers began work on a two-year assessment of status and trends in bioaccumulation of mercury, a strong neurotoxin, in water, sediments, and aquatic species of depressional prairie potholes of the Fort Belknap Indian Community
 - A survey of mercury levels in biotic and abiotic components of wetlands will support selection of subset of pristine and impacted wetland types for more detailed characterization of hydrologic and biogeochemical to wetland species and habitat
 - Researchers established a baseline for comparison against future levels of mercury and evaluated changes of climate/mercury deposition on wetland ecological functions and services for a prairie ecosystem
 - Researchers provided seven scientific presentations, mentored 13 undergraduate students, two PhD students, and three students have obtained graduate degrees in honey bee and colony loss fields
 - Researchers gave four presentations to bee keeping organizations, and engaged with the public five times in a range of formats including presentations and field days
 - Researches published 4 articles in peer-reviewed journals and developed a university honey bee outreach site and pollinator garden, a .5 acre site that serves as a hub of for research and community stakeholder activities
 - Researchers obtained longitudinally collected bee samples from commercial bee keeping operations and assessed the pathogen prevalence and abundance associated with these samples
 - Four peer-reviewed journal articles were published on invasive and woody plants in range lands
 - Results were presented to six professional organizations relating to range management and taught to undergraduate and graduate students at MSU
 - Funding was initiated and received for a complementary research project to identify and quantify biotic and abiotic site characteristics including vegetation, disturbance history and climate that are found in cheatgrass-invaded locations in Montana foothills
 - Conifer expansion was studied and organized several stakeholder meetings to discuss possible grant funding for field treatments and applied research
 - Researches provided ecologically-based information to range land and natural resource managers that assisted in developing appropriate management techniques to ensure continued and sustained production of modern range lands

- Projects contributed directly to the training and professional development of two graduate students and three undergraduate students
- Six peer reviewed journal articles were published
- Projects achieved several high impact results that help scientists and society understand the biological controls and physical constraints to coupled N and C dynamics and in terrestrial ecosystems
- Two papers were published in press that address land use nitrogen losses and carbon capture and sequestration in the Upper Missouri Basin
- Considerable progress was made in isotopic analysis of over 130 years of herbarium records for common grassland species in Montana

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: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	8.0	0.0	0.0	0.0
Actual Paid	18.4	0.0	0.0	0.0
Actual Volunteer	32.6	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
555048	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
361960	0	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Collaborate with Native American reservations and 1994 land-grant institutions to provide culturally appropriate programming and related materials to Native American families.
- Conduct workshops and clinics that provide active learning and skill development
- Conduct meetings that focus on facilitation and leadership skills
- Develop curriculum and supporting teaching tools for volunteers to use
- Provide training for youth and adult volunteers
- Partner with youth serving groups on state and local levels
- Provide/develop web-based education and information access
- Facilitate small support groups for caregivers
- Develop 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

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	9069	114251	21169	32645

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

Patent Applications Submitted

Year: 2017
 Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	11	0	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of youth enrolled in organized 4-H clubs

Year: 2017
 Actual: 8942

Output #2

Output Measure

- Number of youth participating in 4-H overnight camping programs

Year: 2017
 Actual: 1046

Output #3

Output Measure

- Number of youth and adult volunteers offering support for the 4-H program

Year	Actual
2017	3521

Output #4

Output Measure

- Number of participants in classes and support groups for parents and caregivers.

Year	Actual
2017	470

Output #5

Output Measure

- Number of participants in personal finance classes

Year	Actual
2017	2346

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 trainings 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.
7	Expand research-based mental health educational programming to youth and adults statewide.

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
2017	0

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 38,327 projects related to (STEM) during 2017. These projects included robotics, bioscience, livestock, foods and nutrition, environmental education, plant sciences and engineering. An Advanced Market Livestock Program was created by Fort Peck Reservation and Daniels, McCone, Richland, Roosevelt, Sheridan and Valley counties. The project offered hands-on activities related to using carcass and value-added meat production to strengthen knowledge and provide a skill set with practical and potential employment opportunities.

Results

The program included 65 volunteers 342 youth. The overall rating for the project was 4.5/5 (1=poor, 5=excellent). Students learned from before and after analysis of cuts of meat, how to mix spices, how to make sausage, food safety, equipment safety, and cooking at the right temperature. These skills make them employable by a meat shop, grocery store meat department, or in restaurants. It also gave youth and families the skills necessary to process animals they harvest through hunting, thereby reducing their costs. The Tribal Elder Program and Grandparents Raising Grandchildren groups praised the project for creating a connection between youth and the elderly. Parents of the youth have requested adult classes to learn similar skills. The project also satisfied Indian Education for All requirements mandated for teachers by

state law.

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
2017	0

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 2017, 20,617 youth participated in 4-H activities. Of these 8,942 were members of 4-H clubs. Over 20% 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

Every county has impressive impacts from 4-H programming. A sample includes: Gallatin County (400 members): 100% who completed a survey indicated they developed greater communication skills because of 4-H, 56% said they were better able to see another persons' point of view and 96% said they improved their ability to prepare presentations.

Chouteau County: Eight junior leaders demonstrated improved leadership, communications, organizational and decision-making skills by teaching livestock classes to 4th and 5th grade students.

A local fireman commended the Fergus County office because a young lady who had responded to an emergency event with skill and poise, said it was because of what she learned in 4-H.

Testimonial: I have taken several 4-H projects from market and breeding projects to sewing, woodworking and gardening. Through these projects I have learned that you don't always get it right on the first try. Persistence will pay off if you do not give up. It is not how your project turned out but what you learned along the way. I have also learned that sharing knowledge with others can be even more rewarding.

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
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Leaders, both 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 of 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

The 4-H motto, learn by doing, is applied to leadership through experiences that allow youth to lead. Youth receive training and guidance in preparing programs such as 4-H project days, camps and service learning activities. Youth are called upon to complete projects or events from idea to implementation and evaluation. In addition, youth manage all aspects of club activities from conducting needs assessments, running organized meetings, budgeting and resource management. Individual counties and regions provide extensive opportunities for leadership training including volunteer certification.

Results

Each 4-H volunteer impacts between 20 and 36 kids. By offering training and certification opportunities for volunteers, counties reported an increase in participation of 50%. Statewide, there were 3521 reported volunteers who contributed nearly \$2 million in economic value to their communities. Reports indicate that 75% of youth who participate in 4-H leadership programs also had leadership roles in school, church, and other community organizations.

Carbon County: Youth leaders planned and implemented a Prom Dress Drive to help teens access affordable dresses, planned and led a Project Day and Clover Camp and prepared a presentation for MSU Leadership including the President, all the Vice Presidents, all the Deans and other faculty and student leaders. They provided an overview of 4-H and shared personal stories about how 4-H had impacted their lives and their community.

Testimonial: As a young 4-Her I struggled with leadership. I was not a natural leader but I learned. Through the encouragement of leaders and fellow 4-Hers, I have become a leader. I never thought I would say that.

4. Associated Knowledge Areas

KA Code	Knowledge Area
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
2017	0

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 36 education/support groups in 32 communities across the state, including on the seven Indian Reservations. Efforts to better

reach minorities were successful, 33% of the 405 direct participants were Native Americans; and nearly a quarter were male. Newsletters are sent through the mail and electronically to 982 contacts.

Results

In 2017, PTC was expanded to include grandparent caregivers (GrandCares) and 15 participants took that version. All participants made statistically significant gains from pre to post test on feeling confident asking for help, understanding emotions and finding ways to keep up with self-care. Sixty percent strongly agreed they felt more confident in caregiving following the class and 71% were making changes to better care for themselves. 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 950 through newsletters, listservs and web contacts. Evaluation of participants concluded that grandparents showed statistically significant improvements in their awareness of resources to help them in their role, confidence in asking for help from community resources, ability to network with others and ability to find enjoyment in their grandkids. The evaluation also showed that the program did not help with stress, coping skills or better self-care. This further supports the need for expanding the new GrandCares program.

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 trainings 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
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Increased knowledge about personal finance topics leads to improved decision making and better financial security for individuals and families. When people have good financial security, they are less likely to need government and community safety net programs (food bank, supplemental nutrition, Section 8 housing, etc.) Montanans of all ages can benefit from learning about the need for estate planning as 70% die without writing a will. The average age of farm operators is 58. During the next decade many operations will be passed down to the next generation. Many don't realize how property is titled impacts who receives it if they die without writing a will.

What has been done

Solid Finances is a web-based adult financial series with the goal of improving the financial literacy of working adults. Classes include topics such as banking, health insurance, avoiding financial scams, taking the mystery out of retirement planning, working with investment professionals, budgeting for your good life, organizing your financial records and more. During 2017, 634 people attended 18 Solid Finance webinars and the recordings were watched an additional 1069 times.

In addition, Extension offered 60 Estate Planning classes that were attended by 1840 people in communities statewide. Estate planning information was also offered via MontGuides (factsheets), radio programs and newspaper and magazine articles.

Results

Solid Finances:

62% of attendees obtained their credit score after participating in the Credit Score Session.

50% of attendees increased their contribution to their Health Savings Account or Flexible Spending Account after learning about them.

82% of participants calculated the amount of money they will need for retirement.

Estate Planning:

75% of participants said they learned a lot from the presentation.

15% intend to write a will in their own handwriting.

30% indicated they will review their will.

45% will see an attorney about executing a will.

94% will discuss estate planning with a spouse or other family members.

91% will review their beneficiary designations.

Marsha Goetting, the MSU Extension family economics specialist, earned the 2017 Western Region Excellence Award from Cooperative Extension, USDA NIFA and APLU.

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

Outcome #7

1. Outcome Measures

Expand research-based mental health educational programming to youth and adults statewide.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Mental illnesses are a common problem, affecting 25% of the U.S. population each year, with 6% having serious mental illness. The prevalence of mental health problems are even greater in Montana where the suicide rate is nearly twice the national rate (Montana Strategic Suicide Prevention Plan, 2015). There are large populations at high risk of mental illness including Native Americans and veterans, and the rural settings have limited mental health treatment resources. Thus, Montanans frequently face mental illness in their lives and communities. In rural Montana, where healthcare services are scarce, mental health literacy is critical as family members and friends may be the first to identify changes in a loved one needing professional services.

What has been done

To address the mental health needs of Montanans, MSU Extension has joined with the MSU Center for Mental Health Research and Recovery (CMHRR) to implement mental health literacy and suicide prevention programming. Many Extension faculty have been called upon to support the mental health efforts in their counties. The subject expertise in youth and family, and the outreach role of FCS and 4-H Extension field faculty positions them to scale-up educational programming around mental health. Two programs have been implemented. To increase mental health literacy, MSU Extension held a Mental Health First Aid (MHFA) training. To assist youth in understanding mental health issues and learn coping skills to reduce suicide and suicidal thoughts, the Youth Aware of Mental Health (YAM) was taught in six schools to 143 youth.

Results

For the Mental Health First Aid classes, we compared the number of correct responses on the pre-opinion survey to the number of correct responses on the post-survey of knowledge gained. Overall the average score for the pre-opinion survey was 67% and the post-survey of knowledge gained was 100%. Law enforcement/first responders were a target audience and during 2017, 32 took the course. On average adult participants taking the 8-hour Mental Health First Aid course

increased their beliefs and knowledge about individuals with mental illness by nearly 33%. Nearly all participants gained knowledge and skills on how to assist in a mental health emergency and increased their knowledge of mental health literacy.

Youth Aware of Mental Health was taught in six schools to 143 youth. A total of eight classes were held. A presurvey was completed and a postsurvey will be completed three months after the end of the classes, therefore we do not have outcome data as of the end of 2017.

4. Associated Knowledge Areas

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

MSU Extension's work in youth and family development is intensive and often very specific to the needs of individual communities. Montana 4-H continues to be the largest youth organization in the state. Efforts continue to be underway to better track impacts from a regional and statewide level, as opposed to only local.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Mental Health First Aid class participants increased their score from a pre-survey to post survey from 67% to 100%. Nearly all participants gained knowledge and skills on how to assist in a mental health emergency and increased their knowledge of mental health literacy.

Solid Finances:

- 62% of attendees obtained their credit score after participating in the Credit Score Session.
- 50% of attendees increased their contribution to their Health Savings Account or Flexible Spending Account after learning about them.
- 82% of participants calculated the amount of money they will need for retirement.

Estate Planning:

- 75% of participants said they learned a lot from the presentation.
- 15% intend to write a will in their own handwriting.
- 30% indicated they will review their will.
- 45% will see an attorney about executing a will.
- 94% will discuss estate planning with a spouse or other family members.
- 91% will review their beneficiary designations.

Key Items of Evaluation

- Montana youth participated in 38,327 STEM projects.
- 4-H youth on the Fort Peck Reservation and six northeast Montana counties learned advanced meat processing techniques that increased their employment opportunities, taught them the skills needed to process their own hunting harvest and connected youth and elderly in culturally important activities.
 - Gallatin County (400 members): 100% who completed a survey indicated they developed greater communication skills because of 4-H, 56% said they were better able to see another persons' point of view and 96% said they improved their ability to prepare presentations.
 - A local fireman commended the Fergus County office because a young lady who had responded to an emergency event with skill and poise, said it was because of what she learned in 4-H.
 - 3521 4-H youth and adult volunteers contributed nearly \$2 million in economic value to their communities.
 - Following Powerful Tools for Caregivers classes, 60% strongly agreed they felt more confident in care giving and 71% were making changes to take better care of themselves.
 - When grandparents care for their grandchildren rather than having the kids be formally in the foster care system, the state of Montana saves more than \$213,000/day. MSU Extension provides resources for these families to be successful.
 - MSU Extension family economics specialist, Marsha Goetting, earned the 2017 Western Region Excellence Award from Cooperative Extension, USDA/NIFA and APLU.
 - 143 youth in six Montana schools received free Youth Aware of Mental Health training during 2017.

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%		0%	
703	Nutrition Education and Behavior	20%		0%	
704	Nutrition and Hunger in the Population	10%		40%	
721	Insects and Other Pests Affecting Humans	5%		5%	
722	Zoonotic Diseases and Parasites Affecting Humans	5%		45%	
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: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	4.0	0.0	6.3	0.0
Actual Paid	5.3	0.0	3.4	0.0
Actual Volunteer	0.4	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
143811	0	65538	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	258617	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
94926	0	48322	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Conduct train the trainer workshops
- Conduct workshops, seminars, meetings
- Facilitate meetings, discussion groups, focus groups
- Develop local and state partnerships
- Develop MontGuides (fact sheets), publications, website materials, video based materials
- Conduct web based, interactive training/education opportunities

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

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	4759	22192	8788	3671

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

Year: 2017
 Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	7	9	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of participants in Strong Women, Arthritis Foundation and other exercise programs facilitated through MSU Extension
 Not reporting on this Output for this Annual Report

Output #2

Output Measure

- Number of food safety and nutrition related MontGuides distributed by MSU Extension Publications

Year	Actual
2017	0

Output #3

Output Measure

- Number of adult participants in EFNEP/SNAP-Ed

Year	Actual
2017	1063

Output #4

Output Measure

- Number of participants in all levels of ServSafe classes

Year	Actual
2017	0

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.

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

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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, 54 Extension agents and health care providers in 36 counties have been trained as facilitators.

Results

Mountain Pacific Quality Health gathers all data from each site, analyzes, and disseminates the data to local DEEP facilitators and to Medicare. Additionally, facilitators collect evaluation data from class participants which is then sent to Mountain Pacific for analysis.

HBA1c levels improved from 7.4% to 7.2% in 2017. For those who are unfamiliar with this level, it represents the average blood sugar a person has over time. A recommended goal for most people with diabetes is 7%, so this drop in A1c levels is very significant.

The next improvement was the systolic blood pressure improvement. This is significant with a decrease from 138.4 to 128.4.

There was also a significant drop in the LDL - Low-Density Lipoproteins which is the "bad" cholesterol in one's body. This was a new and exciting change which indicates participants are making behavior changes in their diet which is bringing their cholesterol down.

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 #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

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

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. Rural residents can improve their nutrition by increasing knowledge and ability to grow, preserve and prepare local foods.

What has been done

MSU Extension offers classes and longer-term programs that teach and mentor individuals in selecting, growing, raising, preparing and selling their own home-grown food to improve the health of families and communities. As an example, in 2017, Extension helped create a second community garden on the Fort Belknap Reservation and also increased the number of farmers markets from four to six. They offered classes on which varieties to plant, helped families plant, answered questions and provided trouble-shooting throughout the season, offered classes on harvesting and preserving the bounty and finally provided a venue for families to trade or sell their produce and preserves. These programs heavily involve volunteers and are often are multi-generational.

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. During 2017 participation in food system development activities increased 16%.

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
2017	8166

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 8,166 youth and adults in 2017. 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 made improvements in the following areas: Think about making healthy choices when deciding what to feed family 45%; improved frequency of physical activity 44%; improved at least one food resource management practice (plan meals, compare prices, use grocery list, does not run out of food) 77%, improved one or more food practices 86%. Percent of children who made improvements: diet quality 79%; physical activity 28%. SNAP-Ed specific behaviors improved (adults): improved how they thought about healthy food choices for family 45%, improved frequency of physical activity 38%, improved food resource management strategies 77%, improved one or more nutrition practice 86%. SNAP-Ed improved behaviors (children): diet quality 77%, physical activity 26%.

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
2017	0

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. 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

Effort is underway to collect statewide data for this program in the coming year. An example for this year is Custer County where 93 adults and 74 youth completed training. All level 1 participants passed their certification exam and possessed the knowledge needed to reduce the number of food borne illness incidences. The Level 2 participants improved their knowledge of food handling skills and personal hygiene. One of the largest impacts was the training at the Pine Hills Youth Correctional Facility and at Custer County District High School. Youth who are ServSafe trained have increased opportunities to obtain employment because they are already trained in food safety. Having increased skills and certification is particularly important for youth who have been incarcerated.

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 #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
2017	0

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. In Ravalli County, 333 youth and adults participated in food preservation programming. As a service, the office offers testing and evaluation of pressure gauges. Of 31 tested in 2017, three were determined to be unsafe and 14 were inaccurate but could be corrected with adjustments. Survey Results of the adult curriculum (n=133) were: 92% understand the importance of using USDA standards for preserving and processing foods safely; 92% understand the basic process for preserving foods in a hot water bath or atmospheric steam canner; 83% understand the reason, process and necessity for pressure canning foods; 83% are knowledgeable about the process for handling food safely from selecting the item to preserving and then storing. Youth curriculum: 97% understood that boiling water canning is based on science; 95% understood that canned food products last longer than fresh, uncanned food products at room temperatures; and 83% said they would use canning recipes and instructions from the USDA and other science-based sources.

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

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

The Extension Food and Nutrition Specialist left mid-year thus limiting cumulative statewide results.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

- Multistate Research Coordination, Western Region: Coordinated activities among participating states and between multi-state research and integrated research and Extension projects requires certain administrative services and support. For example, interstate travel of State Agricultural Experiment Station scientists and administrative advisers is essential for them to attend ad hoc technical committee meetings, coordinating committee meetings, conferences, and work groups. These activities and the associated expenses must be accounted for through some reporting mechanism. This project will facilitate multi-state research, and integrated research and Extension activities, and permit the accounting of the related expenditures. This project will permit better administration of the Multi-State Research Fund and help to facilitate collaboration and cooperative activities on selected priority topics identified through a regional framework of planned activities.

- Community-Based Natural Products to Improve Human Health: The overall goal is to solve extremely complex issues such as hunger, food security, and a sustainably safe environment (land, water, air). Specifically, we are conducting collaborative research that results from questions posed by the communities-of-focus engaged in the holistic process with scientists, and in so doing together develop sustainable, community-based solutions to issues of food, health, and organic crop production. We will be using field monitoring and field trials after confirmation with laboratory bioassays whose methods have been developed, tested and published by us. In Montana, there is a growing interest in traditional food ways among the Apsaalooke and Northern Cheyenne emanating from the past decade of our collaborative research with students and faculty at the Tribal colleges and local high schools, Chief Dull Knife College, Lama Deer High School, Little Big Horn College, and Lodge Grass High School. There also is an entrepreneurial interest among Native American high school teachers and Tribal college faculty for using existing greenhouses in their institutions to create income streams. New funding from USDA NIFA CSREES and from the Montana Business Research Commercialization Technologies will support this MAES project. This proposal couples sound bioassay methods and field studies with a community-based approach using the holistic process and longitudinal survey methods.

- Marketing and Delivery of Quality Grains and BioProcess Co-products: Use of

conventional synthetic insecticides to protect stored grains is a complicating factor that impacts negotiation of grain sales. In general, decreasing insecticide use without sacrificing quality is the best approach. We propose to reduce grower reliance on these chemicals by further demonstrating the value of using climate and weather to manage insect pests in farm-stored grain in Montana. A reduction in use of insecticides can be accomplished without any loss in quality. This is accomplished by using cool, dry air to aerate the stored grain mass, reducing pest survival and reproduction. This information will be incorporated into a stored products module for a senior level course in integrated management. In controlling insect pests of stored grain, inert dusts are often less used tools. We will test whether nanostructured alumina will be a more effective inert dust than those currently available. Residue tests will determine overall product persistence in processing situations. This should yield a potential new pest management tool for grain storage.

- **Food Quality and Metabolic Parameters Influencing Development and Progression of Fatty Liver Disease:** Tens-of-millions of Americans have fatty liver disease (FLD) and an estimated eight-million of these people will progress to liver cirrhosis. Most cases of FLD are caused by excessive consumption of either calories or alcohol, and therefore, nearly all attempts to treat this disease are behavioral. Indeed, the accepted treatment of FLD is moderation or abstinence at the point of consumption. Unfortunately, the enormous prevalence of FLD indicates that behavioral approaches are not adequately effective. Millions of Americans continue to consume unhealthy amounts of calories and alcohol. This proposal is aimed at understanding the genetic, metabolic, and systemic physiological processes that underlie FLD using a set of three novel mouse models that we have developed which have genetic predispositions to distinct types of FLD. The goal is to understand the metabolic pathways leading to FLD such that one might design dietary, food-source, or food supplement protocols that might eliminate or abrogate the physical manifestations of FLD even in people who continue to partake in high-risk behaviors for FLD. Thus, this work is aimed at testing whether simple and palatable shifts in the nation's food supply or in the USDA's nutritional recommendations might be effective at reducing national rates of FLD.

- **Using Research to Facilitate Production of Antioxidant-rich Berries and Small Fruits in the Northern Rockies:** The opportunities are ripe to expand small-fruit production in Montana. Demand for small fruits is growing in the state and nationwide. In part, the growth in demand is due to an increased interest in healthy eating. Berry-based "nutraceuticals" or "superfoods" have captured public attention and represent a growing market. In addition, local and regional food processors have expressed a strong interest in incorporating these fruits into their products. However, current production is low. Producers lack the basic information concerning which types and varieties are adapted to grow in Montana and the economic potential of these crops. Research is needed to test the feasibility of these new crops. The short-term goal of this project is to determine which small fruits are productive and profitable. We are currently testing over 50 varieties of small fruits including elderberry, dwarf sour cherries, currants, aronia, and haskaps at four sites across the state.

- **Developing Integrated Pest Management Programs for Insects in the Western Triangle Agricultural Region of Montana:** The main focus of this research will be developing sustainable integrated pest management tactics for major pests of wheat, canola, and pulse crops. The ultimate goal of this project will be to provide growers, stakeholders and agricultural professionals with tools and practical research based information on the sustainable insect pest management practices. It will thereby help to enhance the profitability and sustainability of agricultural production systems in the Golden Triangle Agricultural Areas of Montana. Moreover, the project will provide resource materials for growers through outreach and training workshops for growers and Extension agents.

Key Items of Evaluation

- Provided a home-grown soil enrichment that suppresses harmful root boring insects, fungi and nematodes
- Provided a new source of income for small-scale Montana greenhouse owners
- Facilitated entrepreneurship related to development of Montana-based insects for food and feed
- Analyzed trends in attitudes and preferences of Montana residents and college students toward edible insects
- Characterized quality and safety attributes of cereals, oilseeds, and their processed products, and to develop related measurement systems
- Developed efficient operating and management systems that maintain quality, capture value, and preserve food safety in the farm-to-user supply chain
- Organized a multi-institutional framework for the creation of measureable impacts generated by improvements in the supply chain that maintain quality, increase value, and protect food safety/security
- Measured impact of disrupting TrxR1 on liver oxidative stress, and determine whether changes in hepatic lipid accumulation correlate with accumulation of oxidative damage to macromolecules (DNA, protein, and lipid) in liver
- Investigated how changes in hepatic TrxR1 activity affect hepatic energy metabolism, and how changes in dietary energy sources affect hepatic TrxR1 activity
- Characterized the relationship between TrxR1 activity, nucleotide metabolism, and sulfur-amino acid metabolism in cells, and investigate whether the status of these pathways feed-forward through S-adenosyl methionine to impact one carbon metabolism in the liver
- Tested whether dietary selenium content, in the form of selenomethionine, can affect development of FLD and, if so, correlate this to impacts on TrxR1 activity, hepatic oxidative stress, and changes in levels or activities of the other selenoproteins in the mice
- Identified adapted and productive types and cultivars of berries and small fruits
- Assessed effect of environment and management practices on fruit production and phytonutrient concentrations
- Determined attributes of wild, native haskap biotypes
- Educated consumers, producers, and buyers
- Conducted exploratory research on pea weevil and cabbage seed pod weevil
- Conducted biological control of wheat stem sawfly, flea beetles and wireworms
- Monitored technologies using pheromone based trapping for pea leaf weevil
- Introduced and assessed value of new parasitoids for orange wheat blossom midge

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%		70%	
704	Nutrition and Hunger in the Population	20%		0%	
723	Hazards to Human Health and Safety	10%		20%	
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%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2017	Extension		Research	
	1862	1890	1862	1890
Plan	3.5	0.0	0.0	0.0
Actual Paid	3.3	0.0	0.7	0.0
Actual Volunteer	1.4	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
88355	0	1852	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	37809	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
79057	0	48703	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

- Community meetings will be held to determine community values, attitudes and vision on which to develop strategies and action plans.
- Partnering with local economic development entities, agencies, businesses/industry and organizations to implement goals and plans of action.
- Planning for potential disasters that may occur in a community, e.g., EDEN.
- Training opportunities available for people serving on boards, councils and committees in both the public and private sectors.
- 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 and councils

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

2017	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	5596	90136	2488	5632

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

Year: 2017
 Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2017	Extension	Research	Total
Actual	23	0	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of participants in programs to support Community Foundations, endowments and other similar collaborations focused on community sustainability
 Not reporting on this Output for this Annual Report

Output #2

Output Measure

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

Year	Actual
2017	7000

Output #3

Output Measure

- Number of participants helping with community garden projects on Montana's reservations
 Not reporting on this Output for this Annual Report

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	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
2017	0

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.

Results

Liberty County: Raised \$4000 toward a permanent endowment with Montana Community Foundation. Golden Prairie Community Foundation granted \$1000 to local non-profit organizations to aid in community projects including purchasing "jump kits" for EMT training and repairing picnic tables at a local campground.

Culbertson Area Community Foundation: Awarded funds from endowment to: The Culbertson Women's Club towards a bath house and splash pad project; to the Culbertson Saddle Club to improve pens and chutes; to the Roosevelt Medical Center and Nursing Home to purchase new furniture for the chapel; and to the Missouri River Rats 4-H Club for potting soil and bedding plants for the nursing home. Club members worked with residents to plant and care for the beds through the season. The foundation also received its first deferred gift annuity.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development
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
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana county and municipal officials are responsible for managing 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 108 clerks and treasurers and more than 50 elected officials. Overall the program was rated 4.65/5.00. Testimonials from the Institute attendees include:

-A great learning opportunity, very affirming. I return to City Hall feeling rejuvenated & full of hope and new ideas.

-Great conference! I learned a lot about my job & local government in general.

The LGC maintained its seven publications in 2017, managed eight listservs which regular reached more than 7000 emails with timely information to assist in the regular operation of governments and boards, and developed an online course for elected and appointed officials.

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

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 Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Montana saw one of the worst droughts in the state's history in the summer of 2017, coupled by a fire season that damaged nearly two thirds of the state's wild and agricultural land. Several sections of the state were declared as federal natural disasters and emergencies, with thousands of firefighters and hundreds of Montana National Guard members deployed. There were 21 large, active fires that had consumed over 438,000 acres (177,000 ha). By September 20, after rain and snow had significantly slowed most fire growth, the overall burned acreage in Montana was estimated at 1,295,959 acres (524,456 ha).

What has been done

MSU Extension was heavily involved in dealing with emergency and post-fire responses. From serving as Task Force Liaisons for FEMA management teams, to organizing food and supply drives, to moving cattle to delivering emergency supplies, agents took leadership roles across the state and on reservations to do whatever needed to be done. Some examples are included here. 4-H clubs in Richland, Ravalli, Big Horn and other counties did fund and supply raisers for the Garfield Fire Foundation. Pondera County Extension assisted the local Disaster and Emergency Services (DES) coordinator with converting documents and pdf files to image files to post on Facebook for communication to people affected by the Strawberry, Crucifixion and Scalp fires, several times daily over a 5-6 week period. Having a source for timely and accurate information to residents and producers who had livestock summer grazing in the area, kept road traffic minimal so fire crews could do their work.

Results

Garfield County was home to the Lodgepole Complex fire that burned over 250,000 acres: The local agent created a map of the fire zone and identified all impacted land owners, including non-resident/non-ranchers and worked with county road crews to develop maps for work on roads and alternate safety routes to homes and ranches. He also created a way to inspect donated hay and helped landowners mitigate potential noxious weed infestations. He worked with families to manage the stress and fear of losing homes and livelihoods and helped set up a system to manage and distribute donated supplies and funds.

Blaine County: The East Fork Fire burned nearly 22,000 acres in Hill and Blaine County. Extension worked with another volunteer to organize a location for dropping off food and supply donations. Prepared lunches, emergency kits (sunscreen, eye drops, chap stick, toilet paper, burn cream, Kleenex and snacks), water and other supplies and coordinated delivery to hotspots being fought largely by residents. Extension ensured safe food handling and storage during preparation of meals and performed Quick Nitrate tests to help determine if forages would be safe for cattle or they needed to be moved.

The Soils Specialist developed written resources giving producers direction on how the fires impacted soil nutrients and health and what they could do to maintain or restore their soil and gave 10 presentations reaching 360 producers.

Beef Cattle specialist and Garfield County agent: Coordinated a post-fire tour near Sand Springs, MT for scientists and Fort Keogh regarding return to grazing and impacts on plant populations.

They then toured the area and met with livestock producers independently to answer questions. The Beef Specialist also coordinated the update of MSU Extension's extensive "After Wildfire?" publication.

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

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 Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2017	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Empower youth in a variety of programs to develop social, emotional and academic competencies using culturally appropriate, approved methods. Objectives include providing youth development programming in mentoring to develop social, emotional and academic competencies, provide cultural and natural resource 4-H projects, Youth Aware of Mental Health training, and 4-H project clubs.

What has been done

Empowered youth in a variety of programs to develop social, emotional and academic competencies using culturally appropriate, approved methods. Mentored youth (mentee) engage in weekly 4-H learning activities where youth receive homework help and develop a relationship with a safe mentor engaging in 4-H activities. Mentor, mentee and mentee's family attend a monthly family night dinner with family building games and activities, enhancing the developmental assets of youth.

Results

Current data from 5 years of evaluations with YFP youth demonstrates sufficient evidence to continue mentoring. Currently mentored youth on the Flathead Reservation showed competency increases in both social skills (75%) and emotional competence (70%).

Youth also show academic improvement in at least one subject (14%), two subjects (42%), three subjects (21%) and four or more subjects (23%).

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

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

V(I). Planned Program (Evaluation Studies)

Evaluation Results

- Researchers sought to measure agricultural literacy knowledge, perceptions and attitudes and to conduct program or intervention evaluations to assess if programming is having an effect toward the goal of an agriculturally-literate populous that understands and can communicate the source and value of agriculture as it affects quality of life.
- Researchers investigated design strategies for the cleanup and reuse of brownfield landscapes that best regenerate healthy ecosystems and people, and assess to how to best align natural and cultural design elements within brownfield regeneration projects. Research was centered on: 1.) how people perceive landscape characteristics or remediation methods and reuse strategies; 2.) review of landscapes and planting design related to remediation (clean-up) and 3.) principles for the integration of ecological landscape design and landscape performance in brownfield regeneration.
- Researchers investigated the factors that contributed to the successful survival of owning families and businesses as important keys to the successful survival of a community. Researchers explored connections on the simultaneous stress on systems that family business depends upon that may be a contributor to business demise. Understanding the successful survival of owning family businesses is an important key to the successful survival of a community, particularly in rural Montana.

Key Items of Evaluation

- Researchers identified the sources of change and disruption that impacted the family/household, the family firm and the community.
- Researchers examined typology in brownfield regeneration
- Researchers explored existing primary resources on brownfield remediation and redevelopment plants to investigate planting strategies used in site clean-up and

programming and design.

- Research was continued and design took place in finalizing the schematic design of the community park on reclamation land that received last reporting period in Butte, MT
- Researchers assessed agricultural knowledge on food production of Montana youth
- Researchers evaluated existing agricultural literacy programs that relate to increasing agricultural literacy
- A coordinated effort to conduct agricultural literacy was established

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 with 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.