2019 Annual Report of Accomplishments and Results

Montana
Montana State University College of Agriculture (COA)
Montana State University Agriculture Experiment Station (MAES)
Montana State University Extension (MSUE)

I. Report Overview

The NIFA reviewer will refer to the executive summary submitted in your Plan of Work. Use this space to provide updates to your state or institutions as needed.

1. Executive Summary (Optional)
Updates included in the following sections.

II. Merit and Scientific Peer Review Processes

The NIFA reviewer will refer to your Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Process	Updates
1. The Merit Review Process	None
2. The Scientific Peer Review Process	None

III. Stakeholder Input

The NIFA reviewer will refer to your Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Stakeholder Input Aspects	Updates
1. Actions taken to seek stakeholder input that encouraged their participation with a brief explanation	MSU recently adopted a new 2019-2024 Strategic Plan: *Choosing Promise* http://www.montana.edu/strategicplan/index.html. The plan includes three central priorities: Transformational Learning, Scholarship that Improves Lives and Expanding Engagement. In addition, the plan identifies four grand challenges of particular focus for MSU. These are: 1. Caring for our environment: environmental science, design, engineering, architecture and social structure; 2. Promoting wellness in our communities: access and equality in education and health outcomes, community-based participatory research, biomedical sciences and entrepreneurship; 3. Food and fuel security: sustained food systems, precision agriculture, energy production, transmission and storage; 4. Securing the future of Montana: cybersecurity, photonics and optics, defense, governance and public policy. Along with significant ongoing communication with stakeholders, this new strategic plan strongly informs the priorities for COA/MAES and Extension. COA/MAES and Extension, along with the rest of the university, have determined specific metrics that will be tracked over the next five years to determine success in achieving the goals of *Choosing Promise*. These will be reflected in subsequent plan of work documents, as well as through MSU's critical issues and project initiations. In February 2020, the COA/MAES adopted its College and Experiment Station-specific strategic plan, http://ag.montana.edu/strategicplan.html. The five-year plan was developed over a 9-month period with input from faculty, staff, students, alumni, and Montana community members who look to COA/MAES to provide impactful research and education. The plan is intended to guide the College and Experiment Station over the next five years and sets out goals that will ensure the growth and success of transformative education, translational research, and engaging outreach programs that

	benefit Montana and beyond. The plan has seven focus areas, with 2-3 specific objectives for each focus area. The focus areas include: 1. A people-driven environment 2. Impactful research and development 3. Transformational teaching and learning 4. Effective and inclusive engagement and outreach 5. Strengthening and growing internal and external partnerships 6. Strategic stewardship of resources 7. Transparent and effective communication The COA/MAES strategic plan was developed to provide direction for the College and Experiment Station to make significant advances toward meeting its missions, and also to align with the MSU *Choosing Promise* strategic plan. The critical issues identified by MSU align with the basic program areas that have traditionally been part of COA/MAES and Extension. The specifics will continue to be refined with the new plan of work process. The critical issues are Agriculture and Natural Resources, Family and Consumer Sciences, Community Development, and Youth Development.
2. Methods to identify individuals and groups and brief explanation.	None
3. Methods for collecting stakeholder input and brief explanation.	None
4. A Statement of how the input will be considered and brief explanation of what you learned from your stakeholders.	None

IV. Planned Program Table of Contents

V. Planned Program Activities and Accomplishments

Please provide information for activities that represent the best work of your institution(s). See Section V of the Guidance for information on what to include in the qualitative outcomes or impact statements. Add additional rows to convey additional accomplishments. You may expand each row as needed.

No.	Title or Activity Description	Outcome/Impact Statement	Planned Program Name/No.
1.	Relationship of Growth Path to Carcass Composition and Meat Quality.	One of the greatest challenges for livestock production is capturing some of the added value for the cow / calf and feeder lamb operations. The increase in ranchers participating in alliances, where end product is important, has led to a greater interest in the effect of production and management decisions on the final product than has been seen in the past. The MAES researcher found relevant gene expression differences between Standard and Choice grade carcasses. There were 49 down-regulated genes and 113 up-regulated genes in the comparison between adipose tissue from Standard and Choice carcasses. This potentially demonstrates that intermuscular adipose tissue can play a bigger role in meat quality and tenderness levels than currently known. (Change in knowledge)	Animal Sciences 1
2.	Custer County Extension Agriculture and Natural Resources Agent is a Key Resource for Farmers and Ranchers During a Harvest Season with Excessive Precipitation.	2019 has been a challenge with record amounts of precipitation in some areas of the county and timing preventing harvest of high-quality forage crops, cereal crops sprouting in the field, and low-quality grazing. Services and support from Extension to farmers and ranchers with these issues include forage sample collection, laboratory testing, in-office nitrate risk evaluation, and ration development utilizing the Montana Brands nutrition balancing computer software. The importance of laboratory analysis came to light as hay producers looked for ways to place value on hay offered for sale and those feeding hay. Rainfall between swathing and baling causes a loss of quality and many try to evaluate this loss based on color change. The unfortunate circumstances have provided opportunity to educate growers how adequate feed value may still exist even when moisture has caused the	Animal Science 1 Plant Sciences 2

		hay to change from green to brown. The agent's assistance provided planning tools for livestock owners and hay producers to develop a viable plan to utilize the lower quality hay produced this year to meet livestock winter feeding needs as well as a means to value the hay based on feed quality and palatability. (Change in knowledge. Change in action)	
3.	Winter Grazing and Feed Supplementation Strategies to Improve Animal Health, Feed Efficiency, and Sustainability in Montana.	In Montana, winter-feeding concentrates beef cattle for 4-6 months, potentially impacting soil and water resources, and is the major variable cost for producers. The MAES research team confirmed that metabolic rates were lower in winter than summer. The researcher developed additional funding to measure heart rate every three hours 24/7 using implanted heart rate loggers in two studies. This research effort will help determine the metabolic profiles (metabolomics) and gene expression (functional genomics) concurrent with our metabolic measures. Improved understanding of these factors should allow ranchers to make feed source decisions that improve animal health and feed efficiency. (Change in knowledge)	Animal Sciences 1
4.	Understanding the Underlying Physiology of Economically Important Traits in Livestock Genetic Improvement to Strengthen the Livestock Industry.	Montana beef cattle production is faced with the challenge of producing more high-quality animal protein with less land, feed resources, and water. This necessitates improved efficiency in production systems which are already the best in the world. This can be done by incorporating genomic information into production and selection decisions. Using this information can accelerate genetic improvement in traits that have been traditionally difficult to select for, such as maternal fertility, production efficiency, longevity, carcass/meat quality, and the impacts of potentially detrimental consequences from reproductive technology such as inbreeding depression. (Change in knowledge)	Animal Sciences 1
5.	Enhancing the Competitiveness and Value of U.S. Beef Through Identification of Beneficial and Antagonistic Gut Microbia to Improve Animal Health and Success**.**	The factors affecting nutrition, health and performance of livestock animals overlap and collectively underpin the economic performance of all livestock operations. Each of these important factors is significantly impacted by microbes occupying the different regions of the animal's gastrointestinal tract. Combining modern molecular approaches to assess composition, functional potential, and small molecule metabolite dynamics with longitudinally collected measures of health and	Animal Sciences 1

		productivity, allowed the researcher to correlate microbial characteristics to health and production traits for isolation and characterization. Metabolites have been identified that correspond to diminished animal health, potentially causing inflammation and reducing barrier function that could lead to systemic infection and impair food safety. Eight microbial species influence animal immune development and function. The goal of this research is to find novel non-antibiotic, consumer-acceptable, direct microbial interventions that optimize neonatal health and productivity, and improve the quality of their products, and to increase profitability and sustainability of U. S. livestock (in particular beef) agricultural industries. (Change in knowledge)	
6.	Improved Understanding of Pathogenesis of *Helicobacter suis* Infection in Pigs and Humans.	This MAES study focused on *Helicobacter suis*, a bacterial zoonotic pathogen that causes gastric inflammation in both humans and domestic pigs. Preliminary data obtained by screening slaughterhouse samples revealed that a significant proportion of Montana pigs are infected with *H. suis*. The researcher is expanding sampling in order to obtain reliable data on the prevalence of this infection and characterize the inflammatory and immune response that *H. suis* causes in the pig and human stomach. These data will fill an important knowledge gap in our understanding of *H. suis* pathogenesis and will allow us to better estimate the risk of human *H. suis* transmission and disease. (Change in knowledge)	Animal Sciences 1
7.	Analysis of Gamma/Delta T Cells and Innate Immunity to Strengthen or Activate Cattle and Sheep Immune Systems.	Bovine viral, bacterial, and parasite-induced intestinal disorders, as well as viral and bacterial-induced pulmonary diseases still cause significant losses to the livestock industry, even though vaccines against many of the causative agents have been available for years. We have seen only a marginal improvement in non-predator calf survival over the past few decades. Strikingly, digestive and respiratory diseases still accounted for nearly 50% of the non-predator deaths in calves. This MAES research focuses on the development of an effective and inexpensive adjuvant therapy for cattle that can be used to help mitigate disease impact. Efforts focused on studies of host innate immune responses against Select Agents. The researcher also expanded studies on *B. abortus* and showed that TLR4 agonists enhance innate immune responses against the bacteria. As a	Animal Sciences 1

		result, a new NIH R21 grant was funded for research testing the use of bacteriophage as countermeasures against *B. abortus* infection. Finally, a new project on *Mycoplasma ovipneumoniae* in domestic sheep was started, which is also focused on innate immune response against this pathogen and the identification of lytic bacteriophage. A USDA/NIFA Seed grant was funded to support efforts in this new project. (Change in knowledge)	
8.	Use of innate immune system adjuvants as countermeasures against salmonellosis in calves.	With the modest funding from this project, the MAES researcher continued testing of novel TLR4 agonists in the Salmonella enteritis model as described in previous reports. Positive results were detected in vivo (reduced morbidity responses following Salmonella infection in 1 to 2-month-old calves as measured by reduced diarrhea and improved animal demeanor), though variability was noted in some experiments that may relate to the "age" of the preparation. In vitro activation experiments continue and will be a significant focus in the coming year. A provisional patent application in partnership with Totem Bio was submitted on the use of these modulators in bovine scours and other infectious disease settings. (Change in knowledge)	Animal Sciences 1
9.	Immunomodulatory Activity of Essential Oils in Bovine and Human Phagocytes. Exploring the use of essential oils to improve bovine or human immune-defense systems.	Mastitis represents one of the costliest diseases of the dairy industry. As mastitis develops it may result in acute or slowly progressing inflammation and can later end in damage of mammary tissue and a loss or decrease in milk production. Currently, antibiotic therapy is one of the main strategies for treating mastitis; however, antibiotics have not been especially effective, and there is concern among dairy producers about value of extensive but inefficient antibiotic therapy. Thus, the identification of alternative methods for combating mastitis is essential. A practical means for dealing with mastitis is to enhance the natural host defense mechanisms of the animal and prevent establishment of chronic infection. The researcher is studying whether essential oils could be used for this purpose. Essential oils are volatile oils found in a variety of plants, including agricultural crops. Because of their value, some small-to-medium sized producers in Montana have diversified by expanding to high-value essential oil crops. Thus, research on the immunomodulatory	Animal Sciences 1 Healthy Living, Nutrition & Food Safety 7

		properties of essential oils has potential to lead to the identification of novel treatments for livestock and humans, as well as contribute additional information on value-added specialty crops for Montana growers. (Change in knowledge)	
10.	Virus-like particles as treatment for *Mycoplasma ovipneumoniae* infections in domestic sheep.	The MAES researcher utilized departmental funding to develop new research studying respiratory diseases in domestic sheep, focused on studies of innate and adaptive immune responses against *Mycoplasma ovipneumoniae* infection. The preliminary research allowed for an accepted USDA/NIFA 2019 proposal. The efforts are focused on new vaccine development for respiratory diseases of relevance to both animal and human health. Preliminary data generated in mouse models of respiratory Staph infections showed that these virus-like particles (VLPs) can stimulate mouse immune systems to better fight bacteria. Future research proposes to determine whether these VLPs can similarly stimulate immune systems of sheep to be better at fighting *M ovi* infections. If we find that to be the case, experiments will allow evaluation of whether VLPs may be a reasonable platform for development of a vaccine to protect or treat *M ovi* infection in domestic sheep. (Change in knowledge)	Animal Sciences 1
11.	MSUE Carbon, Yellowstone and Big Horn County Agents Develop Multi-County Forage Production Series with MSUE and MAES Faculty to Improve Animal Health and Efficiency.	The South-Central Cattle & Forage Series was organized to address the educational needs of farmers and ranchers while reaching people across Carbon, Stillwater, Yellowstone, and Big Horn Counties. In 2018, multiple producers approached MSU Extension in Carbon County with concerns about nitrates in cover crops and grazing cover crops. Producers asked for a way to gain additional income from safely grazing cover crops. MSUE Agents partnered with MAES Researcher Darrin Boss from the Northern Ag Research Center to share his experience and research with grazing cover crops. Information on genetic selection and mineral nutrition were also identified across the region as educational needs. During this series, MSUE Beef Specialist Megan Van Emon helped producers improve their bottom line by implementing a mineral nutrition program and feeding discarded sugar beets to cattle. MSUE Agents Callie Cooley and Nikki Bailey discussed the past and future of genetic selection in beef cattle.	Animal Sciences 1

		Agriculture producers left the program with a greater understanding of cattle genetics, mineral programs, and how to get additional value out of cover crops. Collaborative programs provide an opportunity for agriculture producers to hear locally from county agents, state specialists, and MAES researchers; thereby fulfilling a vital role of land grant university bringing university knowledge to local communities. (Change in knowledge. Change in action)	
12.	Glacier County MSUE Agent Starts Calvin' Fever to Help Ranchers Produce More Live Calves.	Reducing death loss during calving is a high priority for beef producers. Approximately 33% of all calf losses and 15% of breeding cattle losses are due to abnormal or slow-progressing labor (dystocia). Calvin' Fever, a new program for calving preparedness, aimed to educate ranch women on proper calving protocol, dystocia prevention, and newborn calf care. Thirty participants learned about calving difficulties, bull selection, newborn calf care, and preparing freezer meals in advance for busy times on the ranch. The workshop featured a local veterinarian and MSU Extension agents teaching and providing hands-on learning experiences. Calvin' Fever provided education and increased knowledge of identifying calving difficulties and assisting with delivery and care of calves. Workshop participants were multi-generational and actively participated. A 1% reduction in calf death loss as a result of Calvin' Fever would result in an additional 55 weaned calves, creating approximately $55,000 additional revenue and resulting in an economic impact of approximately $1,800 per participant yearly. Attendees gained confidence with their abilities to assist with calving. One producer commented, "You taught me much today. I am confident that I can save a calf. Your knowledge is incredible. I am proud that we have people like you with the time and care to teach me." (Change in knowledge. Change in action)	Animal Sciences 1
13.	Beaverhead County MSUE Agent Helps Producers Manage Forages for Safe Consumption and Increase Marketing Opportunities.	As the largest annual forage producing county in Montana, Beaverhead County farmers and ranchers must be cautious of high nitrate concentrations in feed. Barley, oats, and triticale are the most common nitrate-accumulating small grains. In 2019 the MSUE Agent tested 78 nitrate samples. Using the information from these tests, livestock producers were able to make decisions about the class of livestock and the	Animal Sciences 1 Plant Sciences 2

		ration to be fed. With over 150,000 beef cattle and 15,000 sheep, animal agriculture is one of the largest economic drivers in Beaverhead County. The Southwest Montana Stockmen's Association (SWMSA) and Beaverhead County Livestock Protective Committee (LPC) partner with the MSUE Agent to provide resources for ranchers. The LPC generates funds from local livestock producers to safeguard the animal agriculture industry. The SWMSA provides a forum for producers to learn about legislation, rules, and regulations that will affect agriculture in the county. The Noxious Weed Seed Free Forage (NWSFF) program is vital to maintain the ecological integrity of public lands. Seven returning growers and one new grower participated in the NWSFF program by having 544 acres of forage inspected. (Change in knowledge. Change in action)	
14.	MSUE WSARE Professional Development Program (PDP).	Montana's WSARE PDP program is committed to funding opportunities for agricultural professionals to improve their knowledge and understanding of relevant and current techniques to help farmers and ranchers maintain economic viability while conserving ecosystems, improving biodiversity, and reducing reliance on agrichemicals for pest management. Funding of mini-grants and travel scholarships of up to $2500 form the foundation of Montana's efforts. Proposals are accepted from entities such as MSU Extension, MAES, Federally Recognized Tribal Program Agents, NRCS, and non-profit organizations such as AERO (Alternative Energy Resources Organization), Rancher's Stewardship Alliance, and the Montana Organic Association. Over $45,500 has been awarded in the past two years. Funded projects included increasing capacity of small fruit production in Montana, on-farm demonstration of low sugar potato varieties on the Fort Belknap Reservation, supply chain feasibility analyses training, high tunnel education and outreach, soil health workshops, organic crop production, alternative energy resources, heirloom variety trials, professional improvement tours, livestock production education, technology for precision agriculture, and community gardens. (Change in knowledge)	Animal Sciences 1 Plant Sciences 2 Farm, Ranch and Business Management 3 Integrated Pest Management 4 Energy & Natural Resources 5 Healthy Living, Nutrition & Food Safety 7
15.	Phillips County MSUE Agent Partners with University of Nebraska, Industry, Montana	The annual Jim Schumacher memorial livestock day was well attended with over 25 community livestock producers benefitting from collaborative efforts of the Phillips County MSUE Agent and local veterinary care	Animal Sciences 1

	Fish, Wildlife and Parks, and local veterinarians to Help Local Beef Producers Succeed.	providers. Attendees heard speakers from the University of Nebraska, industry, Montana Fish, Wildlife and Parks, and veterinarians teach about Johne's disease, cattle production efficiency, Veterinary Feed Directive, electronic identification and radio frequency livestock tags, and Chronic Wasting disease in wildlife. These topics are extremely important to the livestock industry in Phillips County, which produced enough red meat to feed 330,000 people and generated revenues of $32.8M in 2016. (Change in knowledge)	
16.	Nutrient Cycling and Management in Montana's Newly Acidic Agricultural Soils.	Soil acidity and aluminum toxicity crop production problems are a recent development in Montana, this has been caused by increased utilization of ammonium-N fertilizers. The potential significance of this project is tremendous as soil sampling data show a downward trend in pH, which is likely to continue unless this problem is addressed. The acidity problems have further been exasperated by the increase in no-till or minimum disturbance cropping systems, which became popular in the 1990s with the introduction of direct seeding equipment. On-farm field-scale trials were conducted in central and northern Montana to evaluate the efficacy of sugar beet lime applications to correct or remediate acid affected fields (pH < 5.0). Replicated small-plot trials helped identify crop species and cultivars aluminum tolerance/susceptibility, and the impact of P fertilization on aluminum tolerance. Lab studies defined the best protocols for estimating lime requirements. This research has been widely used in the Northern Great Plains to assist farmers in managing this newly emerging issue in cropping systems. MAES and MSUE faculty have trained agriculturists and farmers in the importance of proper soil testing, scouting, and treatment of low pH (<5.0) soils. (Change in knowledge. Change in action)	Plant Sciences 2
17.	Sustainable cropping systems through diversified cropping strategies in the northern Great Plains.	Practical knowledge advances are made based on cropping systems field research with multiple crops, sequences, and rotations, in a dryland context suited to the northern Great Plains. Farmers seek operational guidance with regard to nitrogen- and water-efficient crop rotations, and strategies to enhance soil productivity. To help solve these challenges, field research spans simple questions asked in small scale plot studies to	Plant Sciences 2

		more complex questions in large-plot, long-term studies. Active engagement with farmer collaborators at the field scale is used to ground-truth multifactor plot studies. The major outcomes from this research are knowledge pieces that can be assembled to solve the puzzle of sustainability, in a profitable manner. In 2019, 30 cereal, oilseed, pulse and specialty crops were grown in a demonstration trial at Bozeman, MT, to provide educational opportunities for students (AGSC 242 Crop Identification), colleagues, and ag clientele at the 2019 Post Farm Field Day. In 2019, the MAES researcher completed the 4th and final cycle of a cover crop study investigating soil changes due to different cover crop functional groups (brassicas, cereals, legumes, and tap roots). In this 8-yr study, biological, chemical, or physical soil change due to cover crops was limited. Potentially mineralizable nitrogen (PMN) was increased for cover crops vs summer fallow and was greater for 6-species mixes than 2-species groups. Spring wheat yield was approximately 10% greater on summer fallow at Amsterdam but did not differ from cover crop treatments at Conrad. Legume covers increased wheat yield 450 kg/ha at Conrad, but not at Amsterdam. Legume covers also increased wheat protein by more than two percentage points at both locations, important to Montana's wheat markets. The brassica group increased wheat yield by 400 kg/ha at Amsterdam, but not at Conrad. In 2017, the brassica group increased winter wheat yields at both sites. Unlike the case for N-fixing legumes, the brassica response is not well understood. (Change in knowledge)	
18.	Ecology and Behavior of Insect Pollinators, Predators, and Pests.	"Improving pollinator habitat on farmlands is needed to further wild bee conservation and to sustain crop pollination in light of relationships between global declines in pollinators and reductions in floral resources. One management strategy gaining much attention is the use of wildflower strips planted alongside crops to provide supplemental floral resources for pollinators. However, farmer adoption of pollinator-friendly strategies has been minimal, likely due to uncertainty about costs and benefits of providing non-crop flowering plants for bees. Over 3 years, on four diversified farms in Montana, United States, we estimated the potential	Plant Sciences 2 Energy & Natural Resources 5

		economic profit of harvesting and selling wildflower seeds collected from flower strips implemented for wild bee conservation, as an incentive for farmers to adopt this management practice. We compared the potential profitability of selling small retail seed packets versus bulk wholesale seed. Our economic analyses indicated that potential revenue from retail seed sales exceeded the costs associated with establishing and maintaining wildflower strips after the second growing season. A wholesale approach, in contrast, resulted in considerable net economic losses. We provide proof-of-concept that, under retail scenarios, the sale of native wildflower seeds may provide an alternative economic benefit that, to our knowledge, remains unexplored. The retail seed-sales approach could encourage greater farmer adoption of wildflower strips as a pollinator-conservation strategy in agroecosystems. The approach could also fill a need for regionally produced, native wildflower seed for habitat restoration and landscaping aimed at conserving native plants and pollinators. (Delphia, O'Neill, Burkle, 2019) (Change in knowledge)	
19.	Value-Added Agriculture in Montana.	A MAES research team introduced a series of new crops addressing well-defined human nutritional problems including gluten intolerance, obesity, several autoimmune diseases, diabetes, omega-3 deficiencies, and protein imbalances. Nutrition based value-added crop production in Montana may be most sustainable and profitable if technology is transferred to vertically integrated grower groups, enabling growers' participation and benefit from value-added processing and marketing. A central role of this partnership has been to scientifically evaluate the health benefits of these new crops and work to integrate them into the human diet. A unique feature of this partnership was the collaboration between basic and applied scientists to use the most powerful, modern methods of genomics, proteomics, immunology and analytical biochemistry to characterize and validate the human nutritional value of the new crops and of the animal products produced from feeding these crops. The team made progress in six areas of nutrition. 1. Developed a series of high amylose potatoes for Type II diabetes sufferers; now in production in North Dakota and Idaho field plots. The first such cultivar (Huckleberry	Plant Sciences 2 Healthy Living, Nutrition & Food Safety 7

		Gold is now on five Indian Reservations (15 plots)). 2. Developed a high lysine cultivar of Camelina sativa scheduled for a NASA space launch in March 2020 to demonstrate its survival. It is a microgreen cultivar with high omega-3, to be tested for human food consumption for long trips in space. 3. Developed a bio-herbicide (FoxyT14), the technology has the portent of replacing chemical herbicides. 4. We have developed six lines of high protein oats that are expanding in the consumer market. 5. Released a low glycemic line of yellow peas (licensed and in production by the North Dakota Pulse Growers). 6. Developed an assay system for plasmid curing agents in plants (plasmids carry antibiotic resistance and virulence traits from pathogen to pathogen). This is a joint project funded by Gates Foundation (GCE). (Change in knowledge)	
20.	Making the Most of Rainfall: Increasing Water Use Efficiency in Dryland Cropping in Montana.	No-till and minimum till systems have led to water conservation and producers are increasingly intensifying their systems to include a variety of other crops and delaying fallow in rotations. In addition to these improvements, there are various ways to improve productivity in semi-arid areas. Improvements that reduce runoff, that improve water storage in soils, that increase water use by crops (as opposed to deep drainage or consumption by weeds), crop traits that improve the biomass accumulation per unit of water transpired and improve how much of this biomass is converted into harvestable yields all help in improving productivity and water-use efficiency in dryland cropping. Some of these improvements come with improved crop genetics, while others can be achieved with agronomic measures such as proper nutrition or time of sowing. Identification of drought-adaptive traits in field pea, lentil and barley, with a particular interest in root-related traits. These experiments focus on the potential linkage between root growth and yield-related traits. Experiments were conducted with approximately 25 cultivars of field pea, and 20 cultivars of lentil in a multi-year partially replicated design. In addition, a similar experiment was conducted with 8 parent lines of barley and 8 parent lines of wheat which differ in the stay-green and protein concentration traits. Preliminary data from previous years in field pea suggest that the ranking of cultivars as it relates to the	Plant Sciences 2

		proportion of roots at depth shows consistency from year to year, which is encouraging if this trait is to be used in breeding programs. In addition, in lentil, harvest index and the presence of roots in the deeper layer appears to be independent. This is simultaneously surprising and encouraging and suggests there could be separate genetic regions associated with both traits. In barley, stay-green parents appear to retain roots while non-stay-green parents show less roots at maturity compared to flowering. Winter broadleaf crops (winter canola, winter pea and winter lentil) were planted in the fall in 2017 and 2018 and their productivity was compared with spring planted cultivars (planted April 2018 and 2019). These crops are part of an experiment to compare long-term rotations with winter wheat compared to the traditional crop-fallow system or a continuous winter wheat sequence. While on a small area basis (we sampled where plants grew), winter broadleaf did relatively well, on a plot-scale basis the emergence and survival of winter broadleaf was poor in both years and does not yet represent a viable alternative. This said, this research raised some interest among researchers and farmers alike and we performed complementary variety trials for winter canola and winter pea, which revealed some very promising material. (Change in knowledge)	
21.	Locoweed and its Fungal Endophyte: Impact, Ecology, and Management.	Locoweeds are legumes that contain swainsonine, an alkaloid that causes the mammalian ungulate disease locoism. Swainsonine consumption causes severe economic losses as locoweeds have a widespread distribution across the western U.S. The fungal endophyte, *Undifilum oxytropis*, is primarily or completely responsible for swainsonine in locoweeds. Vertebrate herbivores avoid locoweeds presumably because of swainsonine or cues from other secondary metabolites, but locoweed consumption occurs when preferred food plants are unavailable. There have been several reported instances of biological control of locoweed by insects. Understanding herbivorous insect-locoweed-fungal endophyte interactions are important for research areas such as plant/insect/microbe interactions, microbe-induced plant defense against insect herbivores, rangeland management, secondary metabolite production (plant, insect or fungal production control), plant abiotic and biotic stress tolerance, and	Plant Sciences 2

		wild land management. This work can benefit consumers and customers by helping to understand biotic stressors on locoweeds may mitigate a toxic alkaloid produced by a fungus, thus protecting the food supply by aiding ranchers that must manage grazing in consideration of the risk of locoism. There is a pattern of mild suppression of plant compounds throughout the growing season when the endophyte is present. (Change in knowledge)	
22.	Building a Decision Support System for Cropping Systems.	The rotational sequence study was established in the 2018-2019 growing season with bulk strips of winter wheat, flax, safflower, barley, pea, and chickpea crops. Crops other than legumes included 2 treatments of full and half nitrogen rates applied at planting. A chemical fallow strip was included as a check. Soil quality parameters of aggregate stability and infiltration rates were measured in fall of 2018 following termination and frost of cover crops. There were no significant differences in infiltration or aggregate stability of the top 0 - 7.5 cm depth due to treatment after 5 years and 2 cycles of cover crops in a cover crop/spring grain cropping system. A new set of cover crops and grain crops were established in spring of 2019 for evaluation. Cover crop biomass accumulated ranged from 1445 - 4290 kg ha-1 with the highest accumulation from dry pea and the lowest following a brassica mix. It was noted where the previous treatment was spring grain at the highest nitrogen rate cover crops yielded significantly more biomass than where the previous spring grain crop was not fertilized with nitrogen. This implies that cover crops grown in a nitrogen rich environment produced a significant more amount of biomass under the same precipitation regime. We will continue to follow this unintended interaction and will sample treatments accordingly. (Change in knowledge)	Plant Sciences 2
23.	Molecular Genetics of Plant Light Responses and Reproductive Development.	From October 1, 2018 to September 30, 2019, The MAES research team performed experiments to measure the phenotypic effects of phytochrome B missense mutations in the C-terminal dimerization domain of the receptor and we renewed a collaboration with Dr. Stefan Kircher of the University of Freiburg, Germany. With respect to the *Arabidopsis* compact inflorescence project, the candidate gene for the dominant CIF2	Plant Sciences 2

		locus described in last year's report did not prove to be the definitive CIF2 gene, because it does not confer a strong cif phenotype when combined with an aca10 loss-of-function mutation. It is now thought that the genetics of the CIF2 locus are probably complex (perhaps not a single gene phenomenon or involving epigenetics). Further experiments addressing this are planned for the coming year. Experiments were done this year demonstrating roles for the BON calcium-binding proteins and the SCM receptor kinase in cif signaling. Yeast two-hybrid experiments were done showing that these proteins physically interact with each other and with the ACA10 calcium pump. Hence, we envision formation of a SCM/BON/ACA10 protein complex at the plasma membrane as a mechanism in cif signaling. Progress was made on the cif3 mutation, which is a T-DNA insertion allele. There is now evidence that is an epi-allele which causes a cif phenotype not by knocking out the gene in which the T-DNA is inserted but by altering DNA methylation of the chromosome region flanking that gene. This DNA methylation reduces the expression of an adjacent gene, APC13, which encodes a subunit of the anaphase promoting complex. It is hypothesized that this epigenetic effect alters cell division in the shoot meristem following the transition to flowering, giving rise to a floral cluster. (Change in knowledge)	
24.	Production Practices for Small Farms.	This new MAES research effort focuses on locally produced vegetables that are increasing in popularity throughout the U.S. and in Montana. It is possible to produce a surprising variety of vegetables here in Montana, especially by extending the season through use of simple unheated greenhouse-like structures called high tunnels or light fabric covers. This project evaluates the use of these season extension tools for a variety of vegetable crops being grown in Montana. Additionally, this project aims to help local farmers identify the best cultivars of vegetables for our unique climate and to manage compost, manure, other soil amendments, and cover crops for long term soil health. We communicate our results to farmers through an annual field day held at our research farm, and to students through extensive student participation in our projects. (Change in knowledge. Change in action)	Plant Sciences 2

25.	Microbial Solutions for Sustainable Agroecosystems.	Results from the first year of this study showed that in irrigated alfalfa, active fungi (*Azospirillum*, *Azotobacter*, and *Bacillus*) increased from 7.4 ug/g soil in the control to 15 ug/g soil in plots treated with a complex blend of beneficial microorganisms. The same treatment also resulted in a 50% reduction in total bacteria relative to the control which represents a significant improvement in the fungi to bacteria ratio. Similar results were not observed in the irrigated pasture. Effort in regard to this goal have focused on isolating novel plant beneficial microorganisms from acidic soils. To date, over 40 isolates have been obtained and ongoing work will focus on identifying and characterizing these isolates. Several novel isolates belonging to the genus *Burkholderia* have been sequenced. This genus is known to have many acid tolerant species as well as species that are plant beneficial. (Change in knowledge)	Plant Sciences 2
26.	Cereal Quality and Biochemistry.	Wheat and barley are Montana's most important crops and are of considerable importance worldwide. Their life cycle is characterized by 'monocarpic senescence' - after fertilization, over a time span of a few weeks, parental plants turn yellow and die. Importantly, this process is characterized by massive remobilization of nutrients (including nitrogen, potassium, phosphorus, sulfur and more) from senescing parental plants to the developing grain. Senescence timing therefore influences key agronomic traits including nutrient use efficiency, yield (with late-senescing or 'stay-green' varieties often exhibiting higher yields), grain protein and micronutrient concentration. Senescence onset and rate are controlled by genetic and environmental factors; water deficit stress is the most important external factor inducing early/rapid senescence and leading to lower yield. Funding for this objective was secured from the Montana Wheat and Barley Committee (through December 2019). Prior research by this team identified six varieties and lines had functional alleles of both genes (genotype: +/+); four lines had a functional HvGR-RBP1 allele combined with a non-functional HvNAM-1 allele (genotype: +/-), and three lines had non-functional alleles of both genes, derived from variety 'Karl' (genotype: -/-). Earlier anthesis associated with the functional HvGR-RBP1 allele, combined with later maturation due to	Plant Sciences 2

		presence of the non-functional HvNAM-1 allele (+/- genotype) extends grain fill duration by ~3 days. Longer grain fill may explain a substantial increase in the percentage of plump kernels, a slight increase in test weight and lower grain protein in the +/- genotype group compared to both the +/+ and the -/- groups, yield increases were not observed. Significantly increased kernel plumpness and test weight, combined with no or marginal yield effects suggest that lines with the +/- genotype produce fewer, but larger kernels. (Change in knowledge)	
27.	Small Grain Quality and Molecular Biology.	The MAES research team completed experiments in rice demonstrating that native levels of leaf and seed starch biosynthesis limit plant growth. Increasing the level of both leaf and seed starch biosynthesis increases plant productivity more than increasing leaf or seed starch biosynthesis. The research team transitioned these experiments to wheat by creating wheat with increased leaf and seed starch biosynthesis and have begun to characterize those plants. The team also demonstrated that leaf starch biosynthesis can be upregulated by overexpressing the WRKY76 transcription factor in leaves. An additional trait of interest we are studying is genes impacting wheat and barley pre-harvest sprouting. They are studying ways to specifically select for wheat and barley that is resistant to pre-harvest sprout since pre-harvest sprout results in large economic losses when physiological mature wheat or barley encounters significant rain prior to harvest. Our experiments to create 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. These distinct levels of amylose may prove useful in creating nutritional and end product quality differences. For our third objective, which is focused on characterizing Reduced Height (Rht) alleles, we have identified 16 new alleles and found several in each of the three genome specific copies of Rht that modify Rht function different than the Rht semi-dwarfing alleles currently found in wheat varieties. These are being combined in different spring and winter wheat backgrounds for field testing. They also	Plant Sciences 2

		characterized the impact of Rht alleles upon wheat growth and development and wheat product quality. (Change in knowledge)	
28.	End-Use Properties of Wheat and Barley.	End product quality testing of breeder's samples requires the testing of thousands of early generation wheat samples that are submitted by the wheat breeding programs as well as smaller numbers of samples submitted for end product quality related research projects. Both winter and spring wheat varieties are selected to have dual-purpose end product quality meaning they are excellent in both bread and noodle quality. The primary goals of selection are to ensure selection for high grain protein and gluten strength, high flour extraction and low ash content, good dough mixing and bread baking quality, and superior noodle color and textural characteristics. Various research studies were completed including those involved with testing different varieties for usefulness in improving milling yield and baking quality. The primary outcome is the release of new spring and winter wheat varieties having high end product quality. Several additional research studies were completed with focuses upon end product quality. For example, allelic variation in genes that impact wheat milling and baking quality including the impact of high protein strength genes and those impacting starch type and mixing time were included. The studies included those in which we created harder textured wheat and wheat with modified starch properties. All projects have the goal of identifying ways to manipulate wheat quality traits. This data is instrumental in providing the information necessary to ensure that new varieties will perform as expected in terms of milling and baking quality. This in turn helps to satisfy wheat export markets. The second objective was to collaborate on various research projects designed to allow more efficient selection of wheat grain quality. Numerous projects are planned that should allow us to continue to improve grain quality. Outreach programs that involve meeting with various international trade teams and tour groups are important in creating a positive image of our testing program, Montana State University, and wheat quality both within the state and in export markets. (Change in knowledge)	Plant Sciences 2

29.	Regulation of Photosynthetic Processes in Wheat.	Starch is an important metabolite in both source and sink metabolism. In rice we have shown that yield increases associated with increased starch biosynthetic rates are reliant upon plant nutrition. The MAES research team is examining how starch biosynthetic rates impact wheat yield. The starch regulatory pathway is fairly complex. The research team identified the transcription factor WRKY76 as highly upregulated in rice leaves with increased biosynthesis. The team found that overexpression of WRKY76 in leaves leads to increased photosynthetic rates and plant yield. A second area of research examines how genes that impact yield affect photosynthetic rates. The incorporation of Reduced Height (Rht) alleles into cereals led to yield increases in the 1970s. In wheat, all major varieties have one of two Rht semi-dwarfing alleles. They found that the semi-dwarfing allele Rht-B1b reduces flag leaf photosynthetic rates at anthesis and leads to reduction in seed size, beginning shortly after anthesis. They have identified new A, B, and D genome specific Rht alleles and are testing their impact on plant growth and development. (Change in knowledge)	Plant Sciences 2
30.	Wheat Adaptation, Yield, and Growth Effects of Novel Semi-Dwarf Alleles.	The MAES research team completed a study examining the degree to which Rht-B1b impacts wheat quality traits (plant height). The agronomic results agreed with previous studies; we observed a 25% height reduction, 13% yield increase, and a 2% decrease in grain protein content in the semi-dwarf NILs. However, despite the decreased protein content, the Rht-B1b/Rht-D1b NILs had increased bake mixing time (33%), but reduced loaf volume (7%). We also observed that although the semi-dwarfing alleles decreased kernel weight by 15%, they were associated with a 2% increase in flour yield. Flours prepared from the semi-dwarf NILs had decreased Zinc, Iron, and Manganese while having increased levels of Potassium and Calcium. While completing the quality studies the team has also carried out studies examining how Rht-B1b influences plant growth and yield and have found that Rht-B1b reduces flag leaf photosynthetic rate per unit area by 18% and chlorophyll A content by 23%. Rht-B1b significantly reduced grain protein beginning at 14 days post anthesis with the greatest difference seen at 21 days post anthesis (DPA) (12%). Rht-B1b	Plant Sciences 2

		also significantly decreased individual seed weight beginning at 21 DPA and by 15.2% at 28 DPA. Global expression analysis using RNA extracted from developing leaves and stems demonstrated that genes associated with carbon and nitrogen metabolism are not substantially altered by Rht-B1b. From this study, we conclude that Rht-B1b reduces flag leaf photosynthetic rate at flowering while changes in grain composition begin shortly after anthesis. They have moved forward with field testing new Rht alleles both singly and in combination with currently available semi-dwarfing alleles. These experiments required several rounds of backcrossing and preliminary field testing indicates that several alleles confer intermediate plant height that may be useful in both spring and winter wheat varieties. They also constructed the plasmid vectors required for in vitro testing of the new alleles which demonstrated that Rht alleles that confer intermediate height also have intermediate binding activity to GID1. This work is being continued as we develop backcross populations for field testing under different environmental conditions. (Change in knowledge)	
31.	Winter Wheat Breeding and Genetics.	The ultimate objective of this research program is to develop improved winter wheat cultivars to help Montana agricultural producers stay competitive and in business. Cultivars must not only be competitive for yield but must be of sufficient end-use quality to attract foreign buyers. In addition to development and release of superior cultivars, production research to identify strategies to maximize quality consistency of wheat produced in Montana must be conducted. The breeding program is a classical field-based program but will adapt "new and improved" strategies, tools, and methods necessary to get the job done. Quality objectives are high millability, good bread-making characteristics, and premium Asian noodle color and texture characteristics. The primary output of this wheat improvement program is development and release of improved winter wheat cultivars. To this end, an additional breeding cycle was completed in 2019. Foundation seed of two new hard red winter wheat cultivars, 'Bobcat' and 'Flathead' were released to Montana seed growers in 2019. Variety performance information was disseminated to	Plant Sciences 2

		wheat producers via internet, traditional extension publications, popular press articles, and field day presentations. Research findings were published in scientific journals. (Change in knowledge. Change in action)	
32.	Spring Wheat Breeding and Genetics.	Varieties developed by the project were grown on approximately one million acres in 2019. Attributes included high yield potential, excellent end-use quality, and resistance to the wheat stem sawfly. A new release, named Lanning, was grown on several thousand acres for seed production. Four manuscripts were published in scientific journals. (Change in knowledge. Change in action)	Plant Sciences 2
33.	Plant Disease Management and Detection in Economically Important Crops of Eastern Montana.	The MAES research team developed more efficient and cheaper protocols for determining presence of desirable genetic markers. The DNA extraction protocol for peas was developed and evaluated for accuracy using 3 separate molecular markers for disease resistance. For progeny of crosses between susceptible and resistant varieties, the protocol showed excellent accuracy. A population of 264 seeds were evaluated for accuracy and cost/time benefit. Using a more traditional protocol where someone grows the seeding and extracts the DNA using a kit, the process took 14 days and cost $1,632. This protocol extracts DNA from tissue taken directly from the seed takes 3 days for the same number of seeds and the cost for reagents was less than $77. This resulted in 11 less days, 8 of which had personnel actively working, and saved $1,555. This protocol has the potential to save pea breeding programs substantial time and money when using molecular markers for varietal development. (Change in knowledge)	Plant Sciences 2
34.	Agronomic Research for Profitability and Conservation in Eastern Montana: Sugar Beet Research.	During the period from October 2018 to October 2019, tillage and fertility studies for sugar beet were conducted at one location. The MAES researcher compared conventional tillage to no-till and found no-till had slightly lower plant density, at emergence than the conventional tillage. At harvest, they found no-till treatment produced higher root yield than the conventional till. In the study comparing fall application to spring application to test if there is any nitrogen loss to the environment during the winter period, especially under no-till. The research showed that there was no difference between the no-till and conventional tillage in terms of	Plant Sciences 2

		nitrogen need, but spring application of N had higher root yield than the fall-applied N, indicating that there might be some N loss during the winter period. The researcher also foliar-applied micronutrients to sugar beet in both conventional tillage and no-till and found some micronutrients have positive effects on sugar beet root yield and sucrose concentration. (Change in knowledge)	
35.	Agronomic Research for Profitability and Conservation in Eastern Montana: Sugar Beet and Pulse Crop Variety Trials.	During the period from October 2018 to October 2019, sugar beet and pulse crops variety trials at three and nine locations, respectively. Pea, lentil, chickpea, and sugar beet varieties were evaluated at different environments in Montana. These trials allow producers to select adaptable varieties for growers in various environments of Montana. The variety evaluation reports have been published and delivered to growers. (Change in knowledge. Change in action)	Plant Sciences 2
36.	Agronomic Research for Profitability and Conservation in Eastern Montana: Pulse Crops	During the period from October 2018 to October 2019 a pulse crop irrigation study at one location, and pea protein enhancement study through application of inoculant and nutrients at two locations. Rhizobium inoculants were applied at planting, and then micronutrients and plant growth regulators were applied different at different growth stages. The research demonstrated that granular formula of the inoculants generally enhanced pea yield and protein, and certain combination of micronutrients and plant growth regulators had positive effects on pea yield and protein. In the irrigation study, the researcher found that pea produced lower yield and protein content in the no-irrigation check. Irrigation in early growing stage is critical for pea yield and protein formation.	Plant Sciences 2
37.	MSUE Extension Agents in Ravalli and Missoula Counties Collaborate with New Dark Berry Growers to Support New Crops that Improve Human Health.	MSUE Agents is Ravalli and Missoula Counties partners with and the MAES Western Agriculture Research Center to develop and implement multiple seminars and training sessions for the emerging small fruit and berry growers throughout Montana. This growing industry holds a promise of high per-acre incomes, enabling smaller farms to produce a desirable income from a small footprint of land. In April 2019, a statewide workshop was held in Missoula. Presentations included choosing the right berry varieties, establishment of berry orchards, and disease and pest	Plant Sciences 2 Farm, Ranch and Business Management 3 Integrated Pest Management 4 Community Development 8

		management, and the workshop included a discussion panel for marketing and processing possibilities with the different types of fruit. The growers requested the formation of a state growers association for berries that would increase public awareness about new fruits entering the market and provide an association voice for continued statewide advocacy and development. The MSU Extension Agents from Ravalli and Missoula Counties have been leading the group through the process to form a grower's association, which officially filed paperwork in late 2019. The new Montana Berry Growers Association's first Annual Meeting was scheduled for April 2020 and was converted into a series of weekly seminars due to COVID-19. (Change in knowledge. Change in action)	
38.	Determining the Gut Microbiota-dependent Impacts of Anthocyanin-rich Aronia Berries on Obese Individuals of Distinct Inflammatory Phenotypes.	The overall goal of this project was to determine the inflammation lowering impact of anthocyanin-rich Aronia berries. Inflammation is an underlying mechanism driving the development of several diseases. While an elevation in immune signals in the systemic circulation is commonly attributed to adipose tissue, inflammation is not present in all obese individuals. Adipose tissue must become inflamed, and the inflammation trigger may come from other sources. Microorganisms (microbiome), host tissues, and immune cells residing in the gastrointestinal tract (GIT) are a key source of pro-inflammatory signals that may cause the host organism to become inflamed. Human cohorts who share similar metabolic characteristics but differ in inflammation phenotype have some key differences in the makeup of their GIT microbiotas. Species that may confer anti-inflammatory benefits include Lachnospiraceae, Ruminococcaceae, Parabacteroides, and Oscillibacter, this is a change in knowledge that may be further investigated to develop therapeutic strategies to lower chronic, low-grade inflammation and disease risk. The researcher identified bacterial genera Bacteroides, Phascolarbacterium, and Parabacteroides as candidate microbial genera that may contribute to the high TG response that some members of our human participant cohort experienced in response to a high-fat meal challenge. This is a change in knowledge that may be further investigated to develop therapeutic strategies to lower related disease risk. Research in animal	Plant Sciences 2 Healthy Living, Nutrition & Food Safety 7

		models has identified that aronia berry anthocyanins lower TG responses to a high-fat diet, thus our ongoing research for outcome 2 may help to elucidate the potential role of aronia in attenuating this disease risk factor. (Change in knowledge)	
39.	Microbes and Ecosystem Function: Metal(loid)s, Microbiomes, and Methane.	The MAES research team continued analyzing data gathered from Tenderfoot Creek Experimental Forest with the aim to publish within the next 1-2 years. Other methane related research continues on Yellowstone Lake where they have identified biological sources of methane production that do not involve anaerobic methanogens, but rather aerobic bacteria converting methylphosphonate as a major metabolite that microbes aerobically convert to methane. Current work focuses on methylamine. This represents a major paradigm shift. We have described how microbial arsenite oxidation is ultimately regulated by the bacterial genetic circuitry that controls the phosphate stress response. This is important in that they now have described the environmental conditions that must exist in order for arsenite oxidation to occur. They also showed how the product of arsenite oxidation, arsenate, can substitute for its chemical analog, phosphate, in some types of molecules (e.g., arsenolipids) that provides the cell the opportunity to spare phosphate for critical molecules (e.g., nucleic acids) where arsenate cannot substitute for phosphate. In this past year they published another manuscript that describe in great detail how the PhoR and AioS proteins control gene expressions part of global cellular responses to phosphate limitation and to arsenite. These responses involve numerous cellular functions involving iron, copper, and carbon metabolisms, illustrating that the effects of arsenic contamination of an environment go well beyond the issue of toxicity *per se*. Indeed, fundamental aspects of ecosystem nutrient and metal cycling are affected and or disrupted. (Change in knowledge)	Plant Sciences 2
40.	Fort Belknap Reservation MSUE Team Increases Food Security and Healthy Diet.	The communities on the Fort Belknap Reservation continue to advance knowledge, skill and action toward food security. In 2019, several innovative efforts contributed to an increase in participation by community members. MSU Extension Agents at Fort Belknap engaged in a collaboration with the MSU-Bozeman PATHS program, or "Pathways to	Plant Sciences 2 Healthy Living, Nutrition & Food Safety 7 Youth and Family Development 6

		Agriculture and Native foods, Tribal Health and Sovereignty." This collaboration provided the Fort Belknap community members with seed potatoes of the Huckleberry Gold variety to grow and distribute (See "Value-Added Agriculture in Montana" in this report) for the research that is being applied in this report.), a slow-glucose release variety that can positively impact health and nutrition. The Hays Community Garden was able to expand its orchard holdings through grants from DNRC & Montana Urban and Community Forestry Association. The funds were used to purchase resilient varieties of apple and plum trees, bringing the total number of fruit trees to 31; additionally, the orchard now supports eight grapevines. Community involvement increases each year as members gain knowledge and confidence in their approaches to gardening. A new garden was introduced at the Fort Belknap RV Park on the northern end of the reservation, with 10 raised beds and 10 fruit trees. Two community members have stepped up to maintain the garden and will continue to be part of the planning in future expansion efforts. This garden is a partnership between MSU Extension and the Nakoda Aaniiih Economic Development Corporation. The Lodgepole community garden has expanded its growing area to encompass a larger potato and squash field. Additionally, in a partnership with the Red Paint Creek Trading Post, garden produce is offered through the store to encourage locally-supported agriculture and nutrition. (Change in knowledge. Change in action)	
41.	Fort Peck Reservation MSUE Agent Builds Culturally Sensitive Local Foods and Gardening Programs to Improve American Indian Health and Food Security.	The Fort Peck Reservation MSUE Agent developed an educational program based on rural agri-tourism, working with cultural educational customs, and horticulture practices of Northeastern Montana. In the past few years, the Tribal Extension Garden has been successful in raising awareness on gardening issues, a pumpkin patch, a community garden, and now has expanded to container gardening and post-harvest possibilities. Working with garden enthusiasts, the Community Services Department, and youth groups; participants learned how to grow a garden without having space. Space can be greatly limited for residents, soil may be contaminated, or pest pressures force individuals not to be able to enjoy fresh produce from	Plant Sciences 2 Integrated Pest Management 4 Healthy Living, Nutrition & Food Safety 7

		a garden. This program used hands-on methods to teach participants how to build their own box, barrel, container, or other structure to be able to grow a garden. They learned how to pair certain vegetables together in a small space, and also that different cultivars work better in certain areas. At the end of the gardening season, gardeners learned how to preserve garden produce, compare notes on the gardens they raised, and think about next season. More than 250 people benefited from the activities provided through the program in the last year. Participants indicated that the information obtained was invaluable for feeding their families, conserving water, sharing ideas, networking with other horticulturists, and sparking interest in other horticulture aspects. (Change in knowledge)	
42.	Fort Belknap Reservation MSUE Team Build Partnerships to Strengthen Farmer and Rancher Success.	Fort Belknap MSU Extension continued educational outreach opportunities for local cattle producers and co-sponsored the Rancher's Roundup with Fort Belknap Livestock Marketing Co-Op and Native American Community Development Corporation Financial Services during the local Mid-Winter Fair. USDA, NACDC, MSUE Specialists, NCAT, FSA, Blackfeet ARMP and local community garden leaders presented on relevant agricultural topics. Throughout the year, educational and on-farm events including Livestock Bull Test Day, Private Pesticide Applicator Training, and Farm & Ranch Management Workshops were held. Fort Belknap MSU Extension collaborated with Fort Belknap Livestock Marketing Co-op to provide economic opportunities to local ranchers and encourage new youth producers. The Extension agent aided with the completion of three rural ag loans and two junior ag loans to bring new, young ranchers into operation on Fort Belknap. The workshops provided agricultural producers opportunities to solve their everyday challenges and obstacles. Producers left with knowledge and resources to improve their ranching and farming techniques. (Change in knowledge. Change in action)	Plant Sciences 2 Healthy Living, Nutrition & Food Safety 7 Animal Sciences 1 Plant Sciences 2 Farm, Ranch and Business Management 3 Integrated Pest Management4
43.	Pondera County MSUE Agent Develops Master Farmer Series to help Youth and Next Generation Farmers Learn	The average age of a farmer in Montana is 59 years and increasing, meaning we will more likely be relying on young and beginning producers to contribute to agriculture in the coming years. The Master Farmer program was developed to teach young and beginning producers about crop marketing, soil fertility, integrated pest management, crop scouting	Plant Sciences 2 Farm, Ranch and Business Management 3 Integrated Pest Management 4

	Prepare for Farm Leadership Roles.	and plant staging, crop diversification, and web-based tools to help them make management decisions on their operations. Classes were held once a week for six weeks with experts in each subject area to teach the group. Each class started with dinner, allowing the group to network and share tips with each other based on their own experience. Each class featured presentations by the experts, opportunities for open dialogue with the presenters, and hands-on activities. Twenty-four people attended this course, including young and beginning producers, veteran producers, industry professionals, and spouses of producers who had previously been less involved in farm business. When asked if they were planning on making immediate changes on their farm based on what they had learned in this course, 77% of participants said they would. One producer estimated that the knowledge gained could save their farm $50,000 per year. The changes suggested during the course also reflect an improvement in farm sustainability, including improving soil health, reducing dependency on pesticides, and incorporating new crops into production. (Change in knowledge. Change in action)	Energy & Natural Resources 5
44.	Teton County MSUE Agriculture and Natural Resources Agent is an Important Part of the Front Lines of Invasive Species Discovery.	Teton county received over 100 plants and insects for diagnostics in the spring of 2019. Of those samples one stood out among the others, *Bromus commutatus*, (Meadow Brome, Hairy Chess, Hairy Brome). *B. commutatus* is a warm season annual grass that is rarely found in Montana. In recent years, receiving an unknown grass sample in the office has led to some stress and certain fears as to its identification. With invasive grasses such as *Ventenata dubia* (Ventenata), and *Taeniatherum caput-medusae* (Medusahead) slowly making their way into Montana, any unknown grass-species has the potential to have a profound effect on the local ecology. Fortunately, *B. commutatus* is a relatively benign plant; with a structure and look that is relative to most brome species such as *B. tectorum* (Cheatgrass) and *B. japonicas* (Japanese Brome), the key difference is in the plants size. Meadow Brome is considerably taller (33+ inches) and appears less dense than these other species. Currently the plant poses no risk to Montana rangelands, however while un-common it is still important	Plant Sciences 2 Integrated Pest Management 4

		to keep an eye out for plants that appear out of place in our landscape. (Change in knowledge)	
45.	Sheridan County MSUE Agent helps Farmers Find the Best Options for Crops that were Harmed by a Growing Season of Weather Challenges.	2019 presented weather challenges for producers and the MSUE Sheridan County Agriculture Agent. Below-zero temperatures in February through March preceded calving. With the deep freeze, the ground froze hard and farmers had to wait until the middle of April or later for ground temperatures to warm enough to plant. May and June were dry. Increased July precipitation allowed crops to thrive. Unfortunately, higher than average precipitation continued through fall, and producers had a difficult time harvesting crops. Sprouted wheat was a major concern, along with inability to get into the fields due to excess moisture. A large majority of the Durum that is produced in Sheridan County has gone into the feed wheat category when delivering it to the elevator, which is a major decrease in expected revenue for producers. All of the unharvested wheat and sprouted wheat created an educational opportunity for the agent to talk with producers in Daniels and Sheridan Counties about options for grazing unharvested or sprouted wheat. With all the precipitation, forage estimates for grazing are at an average of 18.43% above a normal year. (Change in knowledge)	Plant Sciences 2 Animal Sciences 11
46.	Powder River County MSUE Agriculture Agent and MSUE Specialists Help Farmers and Ranchers Improve Forage Production and Range Health and Best Practices for Vertebrate Pest Management.	Fifty-one producers attended the annual Southeast Ag Winter Series where they learned about alternative forages and compared annual forages with alfalfa; grazing strategies when high forage nitrates might be an issue; and rangeland restoration and management in response to the explosion of annual plants combined with declining crested wheatgrass populations. In cooperation with two local landowners the MSUE agent organized, publicized and facilitated a prairie dog and pocket gopher control program with the Montana Department of Agriculture which was attended by 42 producers. Participants learned best control methods for both pests, and pesticide applicators earned four recertification points toward their licenses. (Change in knowledge)	Plant Sciences 2 Energy & Natural Resources 5 Integrated Pest Management 4
47.	Blaine County MSUE Agriculture Agent Helps Forage Producers	The MSUE Agriculture Agent helped farmers by testing over 50 forage samples were submitted for feed nutrient analysis. This samples	Plant Sciences 2 Animal Sciences 1

	Save Money by Making Informed Decisions Based on Forage Testing.	represented over 7,500 acres or over 22,000 tons of forage produced in the county. Producers appreciated the low cost of analysis and speed of results. These results allowed producers to develop rations as well as price hay for sale based on quality. In addition, over 40 samples came into the office to test nitrate levels. Less than 10% of those samples came back with elevated levels of nitrates. All elevated samples were still in the safe to feed under all conditions. The results of the nitrate sampling within the office allowed producers to make informed decisions on their feed rations. Producers know their forage is safe and it can be used, thus saving these producers on average $25 per ton ($130,000) by not having to purchase additional feed. (Change in knowledge)	
48.	Gallatin County MSUE Agriculture and Natural Resources Agent Provides Training on Risks of High Nitrates in Forages and Changes the Behaviors of Producers in the County.	MSUE Gallatin County Agriculture and Natural Resource Agent taught about the importance of testing nitrate levels in forage crops during an annual multi-county Crop School. This resulted in the MSU-Gallatin County Extension office tested 73 forage samples in 2019, an increase of 81% from number of samples tested pre-harvest vs. post-harvest increased over 350%. Fourteen producers who tested for nitrates pre-harvest were able to reduce the total amount of nitrates in their forage crop by delaying harvest. One producer greatly benefited from the MSU-Gallatin County Extension nitrate testing program. He brought in a multitude of samples early in the harvest season to test their nitrate levels. Three fields were showing nitrate levels that would lead to strict feeding restrictions had they been harvested the day they were tested. By working with him to delay the date of harvest and continual testing of his forage, the MSUE office as able to help him bring all three of those samples to nitrate levels they would not require any feeding restrictions. He said, “You really saved my bacon and wallet this year”. (Change in knowledge. Change in action)	Plant Sciences 2
49.	Chouteau County MSUE Agriculture and Natural Resources Agent Helps Farmers Learn about Safety, Risk, IPM, Farm Management, and More,	Local farmers learned how to improve their farming operations at the Golden Triangle Cropping Seminar. They learned about risk management in cropping systems, herbicide safety and laws, cropping systems for pest management, mental health awareness for farmers and ranchers, integrated weed management, and herbicide resistance. Twelve producers indicated that they would add more crops into their rotations. Introducing	Plant Sciences 2 Integrated Pest Management 4

	Helping Improve Farms Profitability.	chickpeas into a wheat rotation would yield a $40.00 increase in net income per acre, a $240,000 economic impact. Seven producers indicated that they would improve their safety practices with restricted use herbicides. Enhanced pesticide safety helps individuals and families promote farm health and sustainability. One producer will try different spring or winter wheat varieties ($50,000 estimated economic impact on one 2,000 acre farm, a $290,000 gain. The Golden Triangle MSUE agents hosted two herbicide-resistance meetings. The workshop addressed current status and future directions of herbicide-resistant weeds, management, perspectives from industry, Palmer Amaranth monitoring and management, and improving herbicide efficacy. A total of 87 producers said they will make changes to their operation in resistance weed management. changes in management were not made, producers could see yield reductions of 50%. Potential lost revenue to herbicide resistance would total $4,350,000. (Change in knowledge. Change in action)	
50.	Missoula County MSUE Horticulture Agent Builds Partnerships and Helps Horticulturists, Local Food Producers, and the Public Gain Success in Horticulture and Healthy Lifestyles.	The MSU Missoula County Horticulture program provided education and outreach to support the growing horticultural community in Missoula County. Community partnerships have been valuable to our success. Benson Farm, Caras Nursery, Clark Fork Native Plant Society, Community Food & Agriculture Coalition (CFAC), Garden City Compost, Garden City Harvest, Marchie's Nursery, Missoula Garden Club, Missoula Insectarium and Butterfly House, Montana State Arboretum, Pink Grizzly Nursery, Trees for Missoula, Western Montana Fair, and many local farms have been great supporters of MSU Extension horticulture programs in 2019. Some of our program highlights include: • Hosted Planning for On-Farm Success in partnership with CFAC in which 12 beginning farmers and ranchers learned about creating farm business plans in this eight-week program. • Fruit tree pruning workshop this spring in partnership with Ravalli County Extension taught 25 people about fruit tree health and pruning in a local Missoula orchard.	Plant Sciences 2 Farm, Ranch and Business Management 3 Integrated Pest Management 4 Energy & Natural Resources 5 Healthy Living, Nutrition & Food Safety 7

		• The Montana Berry Growers Conference took place in Missoula in the spring of 2019 with 40 people from around the state attended to learn about growing cold hardy berries in Montana. Presentations included berry orchard establishment, berry varieties, pest, insect, and disease challenges, and marketing opportunities for growers. • Both Master Gardener Level 1 and Level 2 were taught this year and Missoula County Master Gardeners contributed 277 volunteer hours in our community and donated 576 lbs. of homegrown produce to the Missoula County Food Bank. • Supported local food systems by creating a local foods map with the help of Master Gardener volunteers. This map highlights CSA's, farm stands, farmer's markets, and U-pick operations in Missoula County to guide shoppers to places they can purchase locally grown food. (Change in knowledge. Change in action)	
51.	MSUE's Master Garden Efforts Across the State Add Up to Major Community Benefits and Help to Those in Need.	The statewide impact of the Master Gardener Program tracks the contributions of active Master Gardeners who have completed the courses, passed their test(s), and are tracking their volunteer hours (not all volunteers submit their hours for tracking). • Montana 393 active Master Gardeners • In 2019, 140 new Level 1 MG's were taught, and 14 new Level 2 MG's taught. • 7,314 pounds of food produced and donated for those in need, a 190% increase over the previous year. • Volunteers provided over 11,800 volunteer hours across the state in 2019 (63% increase over the previous year). These volunteers contributed over $300,000 in labor to benefit their communities and assist those in need. There are over 1,600 followers on our state MG Facebook page, where we disseminate yard & garden information as well as MG events. "Great program to learn all about gardening and all that goes with it, like starting with what kind of soil and it's fertility, pH and such. Plants are what they eat also, not just humans."	Plant Sciences 2 Integrated Pest Management 4 Energy & Natural Resources 5 Healthy Living, Nutrition & Food Safety 7 Community Development 8

		"Thank you again for a great celebration. Job well done. I learned a ton." (annual statewide Master Gardener awards celebration/conference) It was intense, but a lot of fun! (about the Level 3 course) Great class! Highly recommend. (Level 3 MG) (Change in knowledge. Change in action)	
52.	Sweet Grass County MSUE Agent Demonstrates Alternative Uses for Low-Value Wools in Potato Production.	Blackface, belly wool, and tag wool have historically been low value parts of the wools sheared from sheep. In an effort to find alternative markets for these low value wools, Sweet Grass County Extension embarked on a demonstration project utilizing wool as a soil amendment. Four above ground containers were used to test the hypothesis that wool would improve soil moisture holding capacity, thus improving the pounds of potatoes harvested. Five varieties of seed potatoes were used in the project. Each variety was split equally in the containers with one planting receiving a pound of wool with the seed potato, and the other side being planted directly into the soil media. Soil temperature and soil moisture were measured weekly for the duration of the project. All of the containers were harvested in early October with total weights measured as well as potato size. It was observed throughout the growing season those plants that received wool as a treatment appeared to be taller and more vigorous in their growth. When harvested, it was found that the plants with wool had wrapped their root mass around the incorporated wool. Further, upon harvest, the treatment side yielded a statistically significant advantage in pounds produced. Soil temperature and soil moisture were also observed to be statistically advantageous to the treatment side. This project will be repeated in future years and findings made available to both wool producers and horticulturists. Initial findings suggest that wool as a soil amendment has the potential to improve horticultural production. This could potentially benefit wool producers in adding value to lower value wools while helping horticulturalists improve yields. (Change in knowledge)	Plant Sciences 2
53.	MSUE Blackfeet Indian Reservation FRTEP Agent Teaches Youth and Beginning	The Junior Ag Loan Program and educational programs assists and encourages American Indian youth in financing agricultural projects that are designed to foster healthy, meaningful relationships with adults, assist	Farm, Ranch and Business Management 3

	Ranchers and Farmers How to Manage Their Ag Enterprises and Participating in Agriculture Loan Programs.	in crisis and help continue and revive agricultural traditions on the Blackfeet Reservation. Through one-on-one instruction, young people experience farming or ranching and with their parents manage their own agricultural business, develop financial responsibility, increase assets, and build their own credit. They learn how to develop real business goals, apply for funding, maintain accurate records, and make decisions where to purchase and market their own cattle. When the project loan is paid off, they can make informed decisions based on experience, whether to continue in agriculture. This program is designed to assist Blackfeet youth and beginning farmers/ranchers access credit. Limited access to credit, capital, and a credit history has prevented many from returning to family farms, threatening the sustainability of agriculture on the Blackfeet Indian Reservation. (Change in knowledge)	
54.	Powder River County MSUE Agriculture Agent Empowers Women in Agriculture	The Powder River MSUE Agriculture Agent empowered women in agriculture by providing education and the opportunities to apply information on financial management, marketing, production, human resources, and the legal field. Thirteen women attended the six-week program addressing agriculture loans, noxious weeds, family generational differences, communication, accounting, organic production, livestock health, inter-generational transfer of property, and USDA programs. The discussion-based program has given women the opportunity to develop supportive relationships and share knowledge with each other. (Change in knowledge)	Farm, Ranch and Business Management 3 Integrated Pest Management 4 Animal Sciences 1 Plant Sciences 2
55.	Granite County MSUE Agent and Specialist Help Ranchers Understand the Importance of Having an Estate Plan.	In January of 2019, Granite County MSU Extension invited the MSUE Estate Planning Specialist to engage with local producers as part of the 25th annual Herdsmanship School. Estate planning was identified as an area of interest for local ranchers. The specialist shared information to the group to help them understand estate planning. 43% of the attendees did not have a written estate plan and 12% had not reviewed their estate plan in over 10 years. This interactive program showed different scenarios that occur in Montana depending on how much estate planning has been done for individual family ranches. Participants gained a better understanding of the importance of having a well thought out estate plan to protect	Farm, Ranch and Business Management 3

		themselves and be better prepared for the future generations. (Change in knowledge)	
56.	Broadwater County MSUE Agent Partners with MSUE Family Economics Specialist to Help Families and Businesses Avoid the Costs and Heartaches of Dying Without an Estate Plan.	One of the biggest decision-making challenges for most individuals or business owners is to decide how to transfer property or assets at the end of life. The task can seem overwhelming and some people are reluctant to start the process. Two workshops were held on estate planning. Both were taught by the MSUE Family Economics Specialist. The first session, Families and Legacies: Challenging Decisions, helped individuals and families become more aware of options to transfer property upon the owner's death. Of 41 individuals who attend the workshops, 45% did not have a written estate plan. These individuals received information on how to begin the estate planning process, including information on trusts, wills, property ownership transfer and equal vs. equitable division of property. The second workshop was Succession Planning for the Next Generation of Farms and Ranchers. Nearly 65% of the participants in this session did not have a written estate plan. The specialist explored what happens when a farmer or rancher dies without a plan, equal vs. equitable division of property, ways to avoid probate, and ideas for conversation starters. Over 40 people attended this session as well and are better prepared to begin the difficult process of transferring the business, land and assets to the next generation. (Change in knowledge. Change in action)	Farm, Ranch and Business Management 3
57.	Historic Weather Dataset in Support of Climate Related Research.	A large-scale historical weather data set has been developed and maintained that contains spatially and temporally indexed daily temperature and precipitation data from over 90,000 world-wide locations including 60,000 locations in Canada and the United States for the period 1850-2019. The weather data was internally utilized in several thesis projects and have been externally utilized by the Montana State University researchers, U.S. Small Business Administration, the University of Oxford, the University of Massachusetts at Amherst, North Carolina State University, North Dakota State university, and RMA contractors in studies of the economic effects of localized drought, temperature trended events, and the effects of climatic variables upon economic activity. This	Farm, Ranch and Business Management 3

		data base will prove an essential component in several ongoing and future departmental research efforts. We anticipate its continued use by external research groups and agencies. (Change in knowledge. Change in action)	
58.	Understanding and Improving Agricultural and Food Marketing and Policy.	The project, "An Alternative Approach to Measuring Demand Changes in Meat Markets" considers a revised approach to understanding demand changes in US meat markets. Although an existing index-based method is widely used to identify demand shifts, we consider its theoretical foundation and empirical performance against a proposed alternative. The research showed that when using widely available but highly aggregated annual-level price and quantity data, this alternative better characterizes demand shifts for goods such as beef, pork, poultry, and lamb. For many agribusinesses that require information about market dynamics in their industry, this method is likely to provide a more accurate, low-cost assessment of demand changes over time. (Change in knowledge. Change in action)	Farm, Ranch and Business Management 3
59.	The effects of International GMO Bans on Crop Yield Trends.	A study examining the effects of GMO bans on crop yield trends was completed. Over 90% of U.S. corn and soybeans are planted with genetically modified (GM) seed varieties. A flexible nonlinear functional form was utilized to investigate yield differences for corn, soybeans, and wheat between the United States and the European Union (which bans the use of GM technologies). U.S. corn and soybean yields increased relative to EU yields since the introduction of GM technologies. EU wheat yields (for which GM technologies are not commercially available in either region) continue to increase relative to the United States. Thus, the EU ban on GM technologies has likely increased the difference between corn and soybean yields between the two regions. (Change in knowledge)	Farm, Ranch and Business Management 3
60.	The Impacts of State Legislated Wage Increases on U.S. Head Lettuce Prices.	A study examining the effects of regulatory increases in California farm labor costs was completed. To estimate the impact of future California wage rate increases, an ex ante analysis of labor wage regulatory impacts was developed for the head lettuce industry. An equilibrium displacement model was utilized estimate the direction and size of changes in head lettuce quantity and prices given presumed changes in labor costs based	Farm, Ranch and Business Management 3

		upon California's legislated wage rate increases. The study found that a 20% increase in the wage rate for California agricultural labor will increase the retail price of head lettuce by 7.7% and will reduce the quantity demanded of head lettuce by 4.3%. (Change in knowledge)	
61.	The Impacts of U.S. Money Laundering-Prevention Regulations on Small or Rural Banks.	Research was continued with respect to utilizing data envelopment in estimating the effects of U.S. money laundering-prevention bank regulations upon the relative competitiveness of small and rural banks in states that have legalized the use of marijuana. Results to date indicate that money-laundering-prevention regulations decrease the competitiveness of smaller and rural banks relative to larger commercial banks. A possible result is an acceleration in the rate at which smaller and rural banks are consolidated and/or acquired by larger banks. (Change in knowledge)	Farm, Ranch and Business Management 3
62.	Sustainable Families, Firms and Communities in Times of Change.	The purpose of this project was to examine the impact of community capitals on firm success; and, inform public policymakers about the importance of developing community capitals. Using data from the 2013 Small Business Survival and Demise after a Natural Disaster (SBSD) project, the primary purpose of this study was to examine the relationship between community capital and small firm success after Hurricane Katrina. Specifically, this study examined to what extent individual and aggregate community capitals influence small firm success after a natural disaster. The two main research questions are: 1) Did individual's (owner's) community capital affect small firm success after Hurricane Katrina? 2) Did aggregate community capital influence small firm success after Hurricane Katrina? Firm success was measured by the level of perceived success by firm owners. This research shows that perceptions of strong community and communities pulling together positively impacted firm perceived success after a natural disaster. (Change in knowledge)	Farm, Ranch and Business Management 3
63.	Rocky Mountain Malting Barley Cooperative.	This proposal will establish the Rocky Mountain Malting Barley Cooperative (RMMBC) to meet the needs of an industry that is shifting towards dryland production in the Western U.S. Although barley is well adapted to dryland farming, historic production of malting barley has been in higher moisture to ensure malt quality. In dryland conditions,	Farm, Ranch and Business Management 3

		current barley varieties have an increased risk of rejection due to poor malt quality, resulting in a significant economic loss to farmers of more than half of the potential crop value. Therefore, growers are often reluctant to plant malting barley due to the increased risk, resulting in an unstable malt barley supply for end-users, which will only increase with climate change. In addition, 'all-malt' brewing is a new focus in the beer industry, requiring unique quality traits compared to adjunct-malt brewing, which utilizes additional grains. Currently, most barley breeding is focused on adjunct-brewing, and few efforts exist to improve dryland production. Thus, breeding for all-malt brewing requires a cooperative effort to facilitate this growing sector. Here, we propose a three-year project to establish the RMMBC, bringing together growers, maltsters, brewers and researchers to develop barley varieties adapted to dryland farming with quality traits that facilitate all-malt brewing. The outcomes of this cooperative include (i) the establishment of an academic-industry partnership to design breeding and research priorities for Rocky Mountain barley growers (ii) increased stability for malting quality traits produced in dryland agriculture and (iii) the development of new varieties with enhanced quality for flavor and flavor stability. This cooperative will also facilitate regional production of malt for brewing in the Rocky Mountain region. The MAES research team hosted meetings to build connections between growers, maltsters, brewers and researchers to build the cooperative. Several presentations were given to growers, maltsters and brewers. (Change in knowledge)	
64.	Broadwater County MSUE Agent Responds to Agriculturists' Need to Better Understand the Use and Benefits of Drones in Montana Agriculture	Unmanned Aerial Vehicles (UAVs), drones, may seem like a new technology, but they have been used commercially since the 1980s. However, due to cost and accessibility, their use in agriculture has become more common. Drones can be used for a variety of agricultural applications, including mapping, monitoring, and surveying; spraying; irrigation management; and livestock monitoring. Through a Western Sustainable Agriculture Research and Education grant, programs were offered in Broadwater and Park Counties to showcase potential uses of UAVs on crop and rangeland and how producers can utilize the	Integrated Pest Management 4 2 Plant Sciences 2 1 Animal Sciences 1

		technology. During the programs, presenters covered potential uses, types of UAVs and associated costs, licensing, and FAA regulations. They covered uses for UAVs and remote sensing in cropland, research, rangeland and invasive species management. The programs also featured demonstrations of drones including fixed wing, vertical take-off landing units, and a spray drone. A total of 78 people participated in the programs in Park and Broadwater Counties. A survey was given to participants. On the survey, 98% of respondents strongly agreed or somewhat agreed that they were more aware or knowledgeable of uses of UAVs on agricultural enterprises for cropland, rangeland, and invasive species management. Over 91% of respondents were more knowledgeable about the uses of UAVs for integrated pest management. Additionally, 32 participants indicated potential behavior changes or actions following the program, including purchasing a drone, expanding uses of drones, and exploring opportunities. (Change in knowledge. Change in actions)	
65.	Management of diseases in Montana crops.	Fungicide seed treatments for important pulse crop pathogens have been tested over the years and data contributed to a table of registered products that is updated annually. Research is proceeding on the use of essential oils to manage seedborne and soilborne pathogens of pulse crops for the organic and conventional agricultural industry. Seven essential oils show very good efficacy on a wide range of pulse crop diseases. This work has been published as abstracts at conferences. A real time PCR test was developed to detect Quinine Outside Inhibitor fungicide resistance in *Didymella rabiei*, which causes Ascochyta blight in chickpea. This work has been published and the test is available as a service of the Regional Pulse Crop Diagnostic Laboratory at Montana State University. A three-year project is ending investigating the interrelationships of wheat with pest species wheat streak mosaic virus, wheat stem sawfly and wheat curl mites as well as beneficial species thrips and parasitoids of the wheat stem sawfly. Disease pressure was low but in general agronomic practices to manage disease performed as expected (planting date). Investigations into the relationship between seeding density and yield have shown that increasing seeding density does not result in increased winter or spring	Integrated Pest Management 4

		wheat yields, an important piece of information for growers. A risk model for wheat streak mosaic virus incorporating management practices and pest species is available in a beta version, growers have been educated on wheat streak mosaic virus, and the PhD student is finishing her research in preparation for graduation spring 2020. (Change in knowledge)	
66.	Agrochemical Impacts on Human and Environmental Health: Mechanisms and Mitigation.	Two MAES research teams completed research that confirmed that smooth brome may serve as an alternate host for the wheat stem sawfly (WSS) and therefore, serve as a perimeter trap along wheat fields. No data existed to demonstrate whether WSS infested smooth brome because of preference or proximity to wheat plants. WSS were more attracted towards the volatiles emitted from bromes compared to wheat. Furthermore, the duration of oviposition insertion along with the length of time spent on stem, leaves, oviposition insertions, and quiescence was higher in brome as compared to wheat. There were more eggs per stem in bromes than in wheat. There were significant differences in some volatile compounds collected from both plant species among which some of them have been suggested as behaviorally active compound for female WSS. The Y-tube and volatile profiles provided us further insights to explain the attractiveness of WSS towards brome relative to wheat. A second research team found the identified compound present in the susceptible wheat cultivar (Reeder) compared to the resistant, Conan, producing less amount of attractive compound and hence, being less attractive. This research clarified that brome susceptibility is not just due to the brome growing nearby a wheat canopy and intercepting sawflies or by associational susceptibility but is more likely due to attractive volatiles of smooth brome. (Change in knowledge)	Integrated Pest Management 4
67.	IPM of Pre- and Postharvest Insect Pests of Cereal Grains.	The MAES researcher continues to make progress in the development of new host plant resistance to wheat stem sawfly from a variety of cereal sources. Additional efforts have focused on ecosystem inputs that may have a key role in suppression of wheat stem sawfly by natural enemies. These ecosystem inputs exist in the form of carbohydrate reserves provided by flowering plants in cropland - both by crops and by other incidental species. Semiochemicals remain promising in the monitoring	Integrated Pest Management 4

		and management of wheat stem sawfly. Crop ecosystem resilience, as provided by organic and conventional production approaches, figures prominently in long term management of whereat stem sawfly. Ongoing bioeconomics efforts illustrate the need for integrated and holistic approaches to counter both yield loss and loss of profitability due to wheat stem sawfly and stored grain insects. (Change in knowledge)	
68.	Prairie County MSUE Agent Leads Coordinated Noxious Weed Management Education and Management Efforts.	Prairie, Fallon and Wibaux Counties live with leafy spurge as a permanent problem. More than 25 years of MSU Extension educational programs and sustained integrated weed management efforts have helped contain the leafy spurge infestation to the same area and slowed the spread of the weed. The project began with a grant from Montana's Noxious Weed Trust Fund project and has continued well beyond the grant period. An annual tour still takes place to educate and engage producers on noxious weed management. 2019 tour topics were pocket gopher and prairie dog control, herbicides for control of rangeland weeds, and new regional leafy spurge flea beetle research. One producer reported utilizing recommended control methods learned at the tour for pocket gophers. The noxious weed houndstongue has become an increasing problem in Prairie County due to the easy nature of seed spread via wildlife and livestock. The Prairie County MSUE Agent wrote a Montana Noxious Weed Trust Fund Grant to aid private landowners, public land agencies, and the Prairie County Weed District in coming together to educate producers about houndstongue management as well as implement coordinated efforts to reduce spread of the weed. MSUE collaborated with the Prairie County Weed District to host a Fall Weed Tour where the main focus was on controlling noxious weeds such as houndstongue, Canada thistle, knapweeds, and leafy spurge. Topics covered included the do's and don'ts of fall herbicide applications, herbicide control options for annual invasive grasses, and ATV and herbicide handling safety. Tour participants reported learning new herbicide control strategies and a better understanding of the timing of control efforts. (Change in knowledge. Change in action)	Integrated Pest Management 4

69.	Marketing and Delivery of Quality Grains and BioProcess Coproducts.	A key empirical study assessing the role of adjuvants and formulation in the mitigation of risk due to loss of insecticidal products in spray applications show that spray drift can be reduced by more than 60% by the type of formulation and also decreased by more than 35% in combination with certain specific products added to insecticidal spray. This is due to the influence of the formulation or adjuvant on the size of the droplets in the agricultural spray. These findings have particular importance when considering the balance between maximizing the efficacy of insecticidal applications while minimizing nontarget risk. (Change in knowledge)	Integrated Pest Management 4
70.	AWaRe: a decision tool for Assessment of Wheat streak mosaic Risk.	This project was intended to elucidate how management practices influence a complex pest system in wheat. Due to drought in 2017 and 2018, the epidemic of Wheat streak mosaic virus (WSMV) in the study area was less than expected. However, valuable information was gained on the effect of agronomic practices including type of crop (winter/spring wheat), planting date, seeding rate, crop variety, and insecticides on pest pressure and resulting yields. Low levels of WSMV still followed expected trends; the vector (wheat curl mite, WCM) populations are still present in the area and are moving at the predicted times to facilitate the disease; insecticides do not have a clear impact on thrips populations, a major predator of the WCM; phorate and chlorpyrifos were effective at reducing wheat stem sawfly (WSS) populations, reducing wheat stem cutting and increasing yields, while zetacypermethrin was not, as expected; variety selection was as effective as insecticide to prevent stem cutting by WSS, but there is a yield penalty to resistance. Data collection is in its third and final year in 2019. The software tool to educate growers about Wheat streak mosaic virus risk has been released as a beta version and is being tested with users before full release. Education has been ongoing. (Change in knowledge)	Integrated Pest Management 4
71.	MSUE Extension and MAES Partner to Provide an Integrated Noxious Weed Management Research and Education	Invasive plants threaten the economy and ecology of range and wild lands of Montana. This project educates Montanans about invasive plants, focusing on species' identification, biology, ecology, and management. Several education programs have been delivered including one-on-one	Integrated Pest Management 4 Energy & Natural Resources 5

	Program that Helps Improve Management of Noxious and Invasive Plants in Range and Wildland Settings.	interactions via email and phone calls, in-person presentations, field tours, printed materials, websites, and online training modules. In 2019 the MSUE Specialist conducted 29 presentations across Montana; gave one invited presentation in Oregon and one invited presentation in Alberta, Canada; held a three-day weed management workshop, co-hosted one field day; answered about 30 phone calls and 133 emails; appeared on Montana Ag Live six times; appeared on "Voices of Montana" once; distributed 12 Monthly Weed Posts; published two Extension publications and revised one additional publication; and published three peer-reviewed journal articles. The Montana Department of Agriculture funded Noxious Weed Campaign Coordinator and MSUE Specialist continued to offer the on-line noxious weed course for real estate agents. They also cooperated with Dr. Eric Reille to conduct a general population survey of Montanans to assess effectiveness of noxious weed education over the last 25 years. Post-program evaluations for the 3-day weed management workshop showed 28% average improvement on post workshop evaluations. In the spring of 2019, the impact of the long-standing Monthly Weed Post was evaluated, a two-page publication featuring a specific weed, weed management topic, or a summary of research results that is emailed to about 460 people across Montana and the nation. A convincing majority of survey respondents always (67%) or usually (25%) read the post (n=58). Eighty-three percent of respondents find it very to extremely useful, and 58% share information from the Monthly Weed Post with 1 to 10 people, 18% share with 11-50 people, 5% share it with 51-100 people, and 7% share it with 101-1000 people. When asked “Has the Monthly Weed Post ever changed your approach to managing, researching, or educating others about invasive plants?” 81% answered “yes.” (Change in knowledge. Change in action)	
72.	Ecological Management of Kochia in Irrigated Western Cropping Systems.	Stakeholders from across the northern and central Great Plains of the US have identified kochia (*Kochia scoparia*) as one of the most problematic and economically damaging summer annual weeds. This tumbleweed is currently a threat to sustainable crop production due to a near lack of effective herbicide options, especially in sugar beet-based crop rotations.	Integrated Pest Management 4

		Widespread resistance to many different herbicides groups has increased the need and the desire for IPM-based solutions for managing this troublesome weed. MAES researcher collaborating with other states found that kochia can germinate over a wide range of water potentials. Moisture requirement for kochia germination did not differ between northern and southern Great Plains; changes in moisture requirement may not explain differential kochia emergence patterns across the North-South transect. Data from these experiments was also analyzed using a time-event, three-parameter loglogistic model. Results of this experiment revealed that at optimal temperatures, thermal requirements for kochia germination did not differ between northern and southern region. However, at sub-optimal temperatures, kochia from northern region took less time to achieve 50% germination and had higher cumulative germination than kochia from southern region. This indicates that changes in thermal requirements could possibly explain differential kochia emergence patterns across the N-S transect. (Change in knowledge)	
73.	Richland County MSUE Extension Agriculture and Natural Resources Agent Collaborates with MAES, USDA/ARS, and Other States to Help Montana Agriculture Prevent the Introduction of the Invasive Weed, Palmer amaranth.	*Amaranthus palmeri*, Palmer amaranth, is a devastating weed that can be found in much of the United States. Fortunately, Montana is still one of the State's where this troublesome weed has yet to show up. But infestations have been identified in bordering State's to the East and South of Montana. In an effort to educate agricultural producers about this potential weed, the Richland County Extension Office partnered up with the USDA/ARS in Sidney and the MAES Eastern Agricultural Research Center to host a workshop focused on the identification, biology, control, and overall worrisome properties of Palmer amaranth. The workshop was held locally and broadcast via a webinar to allow for more participants. Presenters at the workshop were local weed scientists as well as specialists from North Dakota and Mississippi where Palmer amaranth has recently become a problem and where they have been dealing with it for some time, respectively. Approximately 130 people attended the program and it was also recorded for viewing later by those who could not fit it into their schedule. As one presenter stated, "Palmer amaranth is a game-changing weed and has driven some producers out of business". It is imperative that	Integrated Pest Management 4 Energy & Natural Resources 5

		all efforts are made in Montana to learn how to identify this weed and prevent establishment if at all possible. (Change in knowledge)	
74.	Commercializing Production of Native Montana Plant Species.	Our flora heritage attracted people to Montana initially and continues to bring visitors to Montana every year. The consequences of not educating and learning about native plants for the purpose of landscaping is that we may continue to escalate the use of non-natives and their required high-inputs of water, energy, and fertility as well as introduce invasive plants that will overrun the larger-scale landscape. Many Montana native plants have their own rustic beauty, yet they have not been tapped for the home landscape. Because we do not know the basic requirements of many of the native plants, it has been difficult to put them into commercial production and advise homeowners on their requirements in the landscape. The MAES team is developing protocols that will help greenhouse growers mass-produce more native perennials so that they become more widely available to the public. The researcher worked with undergraduate students on developing greenhouse protocols for Mountain Hollyhock, Wild Turnip, and Arrowleaf Balsamroot; completed and submitted draft of a greenhouse production study on Arrowleaf Balsamroot and Silver-leaved Phacelia; and Collected final data on native plants in the landscape. (Change in knowledge)	Energy & Natural Resources 5
75.	Glacier, Pondera, and Toole County MSUE Agents Partnered with the Montana Department of Agriculture to Conduct Field Research and Increase Richardson Ground Squirrel Control Options.	Richardson ground squirrels have plagued Rocky Mountain Front producers in recent years, reducing crop yield, decreasing field operation efficiency, and damaging farm equipment. In 2018, a research study was done in Glacier County with Dr. Stephen Vantassel, Montana Department of Agriculture Vertebrate Pest specialist, to determine the efficacy of broadcast baiting zinc phosphide for ground squirrel control. As a result of the project and producer-submitted letters, a special label registration was granted allowing for the broadcast baiting of zinc phosphide. The study was followed up in March 2019 with an educational program on ground squirrel biology and control options to encourage early and effective ground squirrel treatment by producers. Producers attending the event estimated their last three years' yield loss to ground squirrels has averaged	Integrated Pest Management 4

		25% in hay, 19% in canola, 18% in chickpeas, 14% in spring wheat, 13% in barley, and 11% in winter wheat. Using average NASS, 2018 wheat prices, this represents approximately $33,000 in lost revenue per farm, annually. In addition to the lost revenue, producers still have input costs of seed, fertilizer, chemical, diesel, labor, etc. on those acres with no revenue to offset those costs. As a result of the program, half the producers planned to begin control earlier. Nearly 20% of producers planned to begin or improve scouting and monitoring. Other producers planned to change their rodenticide, build bait stations, or increase observations through technology use. MSU Extension agents Kari Lewis, Adriane Good, and Kimberly Woodring won two awards for the program from the National Association of County Agricultural Agents. (Change in knowledge. Change in action)	
76.	MSUE Pesticide Education Program Coordinates Applicator Training to Reduce Pesticide Related Issues in the Landscape.	The MSU Pesticide Education Program coordinates the Montana Private Applicator Program. The Montana private applicator program consists of 5,500 private applicators. In addition, the MSU PEP answers licensing questions and provides valuable pesticide information for pesticide applicators. In addition, non-target toxicity, security of pesticides, sprayer calibration, and pesticide poisonings are a recurring concern of the program. The MSU PEP focuses on these core topics to lower non-target problems, poisonings, and crop overspray; while increasing vigilance in securing pesticides and using pesticides appropriately using IPM. During 2019 MSUE hosted 119 pesticide education program (2,266 participants) that offered Private Applicator credit (2.9 credits per course on average). Over 200 people attended Initial Private Applicator Programs. (Change in knowledge)	Integrated Pest Management 4
77.	Is Carbon Turnover in Riparian Areas Facilitated by Grazing?	Over the past three decades government agencies, regulatory departments, conservation groups and individuals have become increasingly aware of the many ecological services provided by intact and properly functioning riparian areas and wetlands. Another, as of yet, unrecognized service of these unique ecosystems may be their capacity to limit atmospheric CO2 build up through the capture and immobilization of carbon. Considerable effort has gone into learning how riparian areas	Energy & Natural Resources 5

		respond to various perturbations including pollution, dewatering, and livestock grazing. The MAES researcher has quantified total soil organic matter (TSOM) levels in grazed and ungrazed streambanks and quantified sediment accumulation. Initial statistical analyses indicate no difference in TSOM between grazed and ungrazed stream reaches. Preliminary analysis concludes that contrary to current state and federal riparian grazing standards there is no relationship between bank elevation increase/decrease and grazed stubble height. At this early date there is no supportive evidence of grazing induced carbon sequestration. However, there is also no evidence that grazing degrades the riparian system's capacity to capture and hold organic matter. If these early analyses are confirmed through further research; they will help land managers make research-based decisions that better support a sustainable resource. (Change in knowledge)	
78.	Connecting Soils and Streams: Deciphering Interactions of Landscape Legacy and Land Use Recorded in Soils, Groundwater, and Surface Water.	The MAES researcher utilizes strategic modeling to advance 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. Modeling key sites and testing mechanisms driving the interaction of hydrologic systems, nutrient dynamics across soil-water connections, and socioeconomic factors. In the Judith Watershed the MAES researcher and two MSUE specialists collaborated to develop community engaged research that involved stakeholders and community members. “The qualitative results suggest that the people most involved in the project became much more engaged with and concerned about how to address the local NO_3^- problem. The project's research findings were also more compelling to stakeholders because farmers had been involved in designing and interpreting the data, and the research had been conducted under real-world farming conditions. Survey results collected in the final year of the project showed that farmers in the watershed were familiar with and had very positive impressions about the project, and their levels of awareness and concern about NO_3^- issues rose over the course of the	Energy & Natural Resources 5

		project" (Sigler, et al. 2018). Recently, the MAES funding was leveraged with a $20M Montana EPSCoR award to the Consortium for Research on Environmental Water Systems (CREWS), for which the MAES researcher is a co-PI, includes a specific focus on this goal that will be carried out over the next five years. Community education around these projects has included tribal communities, tribal college faculty, other MSU faculty, and MSUE faculty. Data for sites associated with Chief Plenty Coups spring were delivered to Crow tribal members, and an ongoing discussion of these data with the Plenty Coups state park director resulted in follow-up actions to mitigate groundwater contamination by the park septic system and local residential septic systems. (Change in knowledge. Change in action)	
79.	Nutrient Cycling and Management in Montana's Agricultural Soils.	The MAES researcher concluded an ongoing study on soil emissions of greenhouse gases from three diversified cropping management systems including an organic-till, organic grazed (sheep and reduced-till), and chemical no-till. Soil emissions of greenhouse gases, i.e. N2O, CH4, and CO2 were monitored with a vented chamber system following USDA-ARS GRACEnet protocols. This study addressed the overarching question of whether integrated crop-livestock organic systems can be a component of a global strategy aimed at increasing the provision of ecosystems services, while mitigating the emission of anthropogenic greenhouse gases. (Change in knowledge)	Energy & Natural Resources 5 Plant Sciences 2 Animal Sciences 1
80.	Advancing Ecology in the Sustainable Management of Rangeland Systems in Transition.	Introduced species, woody plant expansion, and climate change on rangelands threaten the ability of these lands to provide the ecological goods and services desired by society. An improved understanding of the relationships among range use, vegetation change, and ecological resilience, and the potential interactions with future climatic regimes, is needed to ensure rangeland managers are equipped with appropriate knowledge to best adapt to changing environmental conditions while still providing for the needs of society. The MAES researcher gained understanding of whether revegetation activities would be successful under pressure from cheatgrass invasion from surrounding vegetation. The	Energy & Natural Resources 5

		data suggest that there is a window of at least one-year post trail decommission to establish desirable vegetation. (Change in knowledge)	
81.	Beaverhead County MSUE Extension Partners with USDA/NRCS, BLM, USDA/Forest Service, Montana Department of Natural Resources and Conservation, and the Beaverhead Conservation District to Host Montana's Statewide Range Days.	This year Beaverhead County hosted the 2019 Montana Range Days. This event is comprised of many workshops, exhibits, contests, and tours that allows the future generation of farmers and ranchers to learn more about the 68 million acres of rangeland across the state of Montana. Approximately 300 people participated in the event. This large-scale educational event was a collaboration of the state Montana Range Days committee, NRCS, BLM, USDA-FS, Montana Department of Natural Resources and Conservation, Montana State University Extension, Beaverhead Conservation District, and local volunteers. Beaverhead County offered two tours of the local rangeland and management strategies. Participants traveled to the Helle Ranch to discuss sagebrush management and sheep grazing program. The second tour took place at various ranches around Dillon and was focused on Juniper and Douglas fir encroachment into sagebrush grasslands. The result was seeing 300 new rangeland stewards excited to continue the conversation about good range management. (Change in knowledge)	Energy & Natural Resources 5 Plant Sciences 2 Youth and Family Development 6 Animal Sciences 1
82.	Increasing the Utility of Remote Sensing Information for Montana Land Resources.	This project focused on improving methods of biophysical data extraction from remotely sensed imagery, and where appropriate, applying these improved methods to issues facing Montana land resources. Initial tasks will focus on developing tools for "agnostic image analysis", where multiple analytical methods are automatically tested to determine which will produce the most accurate map for a stated purpose. Current projects related to Montana land resources where these methods were applied include mapping bark beetle mortality in Montana forests and detecting invasive weed species in Montana wheat fields. A Manual for Remote Sensing Image Analysis in Python was completed. This manual was published online at http://remotesensing.montana.edu/python.html, along with all relevant Python code, to enable Python users to extract both thematic and continuous biophysical data from remotely sensed	Energy & Natural Resources 5

		imagery using a wide array of machine learning techniques. (Change in knowledge)	
83.	MSUE Forest Stewardship Program Helps Private Landowners and Forestry Professionals Manage Complex Ecological Forestry Goals Successfully.	Montana has 25 million acres of forested land. Family forest owners own and manage 4.4 million acres, owners of 1.2 million acres participate in MSUE's Forest Stewardship Program. Many of these forest owners realize their forest has need of management and want to make educated choices. They lack the knowledge and confidence needed to begin working their forest. The Forest Stewardship workshops provide the opportunity for participants to learn about forest ecology, inventory their forest, and find resources to help them reach their forest management objectives. The result of participation in the program is a group of forest owners around the state who increased their foundational knowledge of forest ecology; have a management plan as a guide to sustainably manage their forest for health, wildlife, fire resilience, range, recreation; and other uses. These forest owners know how and where to find assistance if needed and are confident in talking with professionals as well as family and friends about their forest management objectives and activities. One participant stated, "I wanted to share some feedback w/ you on our progress post class. We received grants from both the Bitterroot RC&D for fire hazard reduction (logging) & DNRC weed control. Our logging project is nearly complete, only limited hand work remains, seeding done just before the rain hit, & going into our 3rd 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 from class. This helped in justifying our weed control priorities in getting the grant. In addition, the people working w/us are TOP notch; they're the type that can really choose who they work for and have said our informed perspective gained from the class is why they chose to work w/us. We feel the class has paid us back in huge dividends." Many forest owners who attend the workshop manage forest in the urban wildland interface and their management creates a protective buffer of fire resilient forest between under or non-managed publicly owned forests and the cities and towns of Montana. The work done	Energy & Natural Resources 5 Plant Sciences 2 Integrated Pest 4Management 4

		contributes to the forest product infrastructure and helps to support and maintain an experienced forestry workforce. Loggers who do much of the work to meet forest owner objectives have the need to understand what landowners desire. They also have the opportunity to become MT Accredited Loggers through the MT Logging Association. The Forest Stewardship workshop is a keystone class they are required to take. In 2019 a Forest Stewardship Workshop for Loggers was offered. Professionals, including foresters and Extension agents often work with private forest owners and also help organize and teach at workshops. To fill the need for Stewardship Advisor training and basic training for others working with forests and forest owners a workshop was offered to professionals in 2019. Five Forest Stewardship workshops were offered in 2019. Seventy-nine percent of participating ownerships completed the workshop and submitted a stewardship plan. Of those who completed the survey, 95% of participants reported an increase in their knowledge of forest function and species, their ability to make informed management decisions with confidence, knowledge of how to write a management plan and find additional information about forest management, and confidence in talking to other forest owners about the management of their forests. All increased in their knowledge with 100 of participants replying positively about their knowledge of these various items. Over 60% of participants plan to apply for cost-share funds to thin and reduce fire hazards. Plans to manage for specific wildlife species increased for 71% of participants. Management plans include 687 acres of commercial harvests, 2,476 acres of intermediate treatments including pre-commercial thinning, planting, and pruning. Participants plan to implement management practices that conserve or improve 3,282 acres of wildlife habitat, 955 acres for water quality, 3,268 acres for forest health, and 2,810 acres for wildfire hazard reduction and resilience. 34 ownerships were monitored representing 8,744 acres. Over the past five years 3,617 acres were commercially and salvage harvested, 2,486 acres of tree planting, 460 acres precommercial thinned, 268 acres managed for insect and disease control, 504 acres of fire hazard reduction (note that many of these landowners have been	

		doing work on their property for more than 5 years so total acres treated is much more), 57 acres of defensible space, 295 acres of aesthetics, 2,135 acres of riparian/wetland improvement, 228 acres of fish and wildlife improvement, 420 acres for grazing, 420 acres of recreation, over 268 acres of weed control. Twenty people Forest Stewardship Workshop for Loggers. The participants completed coursework by attending the workshop, completing an inventory, writing a management plan for a landowner (in practice), and presenting the plan to a group as though they were the landowner. (Change in knowledge. Change in action)	
84.	Integrated Management of Rangeland Invasive Annual Grasses in Montana.	Invasive weeds threaten rangeland health. Ecological impacts include altered structure, organization, and function of rangeland plant communities. Economically, weeds impact rangeland more than all other pests combined, including billions of dollars spent on control and reduction in livestock and wildlife carrying capacity. Containing existing populations and restoring rangeland severely degraded by weeds is critical for the ecology and economics of Montana agriculture. The MSUE/MAES specialist/researcher sought to improve the integrated management of rangeland weeds in Montana. More specifically, refining revegetation of weed-infested rangeland and investigates the ecology and integrated management of invasive annual grasses (downy brome and ventenata). The researcher developed the first replicated field studies of two commercial *Pseudomonas fluorescens* bio-herbicides D7, ACKSS, and MB906 for peer-reviewed publication. Ventenata, like downy brome, is an exotic winter annual grass of increasing concern in Montana. It was first reported in North America in Idaho in the 1950s and has been reported to invade areas previously dominated by downy brome. Because of its newness as an invasive rangeland plant in the western U.S., there is limited information available on its biology, ecology, and management. Research quantified the impact of planting time on the establishment of native grasses, test the efficacy of *P. fluorescens* strain ACKSS as a biological control (bio-herbicide) for downybrome, and expanded the understanding of invasive annual grass ecology. The results of this research has been shared via extension type presentations throughout	Energy & Natural Resources 5

		Montana, the western US, and Alberta, CAN. Journal articles will be submitted in 2020. (Change in knowledge)	
85.	Ecological Genetics of Invasive Aquatic Plants.	Invasive aquatic plants are a major concern globally, and in Montana, because of their potential impacts on ecosystem functions and services, and high costs of management. Most aquatic plant management research has focused on determining concentrations and exposure times required for certain herbicides to selectively control target invasive aquatic plant species while minimizing non-target effects. However, this research has not historically considered the potential for genetic variation in target invasive aquatic plant species, which may modify the herbicide concentrations and exposure times required to control different populations. In this MAES project, I study genetic variation in the widely distributed and managed invasive aquatic plant, Eurasian watermilfoil (Myriophyllum spicatum L.), which is established in Montana and neighboring states. The first research project compared growth and 2,4-D response of ten hybrid genotypes and two Eurasian genotypes, and found considerable variation among hybrid genotypes, although on average they grew faster whether treated with 2,4-D or not. The second paper compared growth and endothall response for a specific hybrid and specific Eurasian genotype present in the Jefferson Slough in Montana. Again, we found the hybrid genotype on average grew faster, although both genotypes were similarly susceptible to endothall. The third paper used experimental crosses to compare vegetative growth rates of pure and hybrid watermilfoils, and found that hybrid watermilfoils grew faster than parentals, suggesting heterosis. Also related to the first objective is an ongoing study in Minnesota comparing the control efficacy of several herbicides on Eurasian, northern, and hybrid watermilfoil genotypes in approximately 10 lakes (Newman and Thum, unpublished). Regarding the second objective, the researcher is comparing temporal changes in the composition of watermilfoil populations as part of a grant in Minnesota (Newman and Thum, unpublished). Finally, regarding the third objective, I have collected ~30 genotypes over the past couple of	Energy & Natural Resources 5 Plant Sciences 2

		summers, and my lab is currently screening these genotypes for growth and herbicide response, focusing on the commonly-used herbicides 2,4-D and fluridone. We have completed screening of 13 genotypes for fluridone and have identified two distinct fluridone resistant genotypes as part of this work. (Change in knowledge)	
86.	Containment, Augmentation and Release of Exotic Biocontrol Agents.	The primary objective of this service-related project to maintain and safely operate the Montana State University Biological Control Containment Facilities. Related biocontrol work contributes to the selection of new biological control agents for the control of several noxious weeds; including Russian knapweed, hoarycress, invasive hawkweeds, ox-eye daisy, and rush skeletonweed. The MAES researcher collaborates with county, state, and Federal agencies to fund and expand biocontrol research and distribution of biocontrol agents. Control agents are distributed through partner agencies across Montana and the western US. The time-consuming development of biocontrol agents and establishment of approved agents on the landscape provide much needed flexibility to land managers and reduces dependence on herbicide-based solutions. (Change in knowledge)	Energy & Natural Resources 5
87.	Reducing Off-Target Pesticide Application.	"Loss of crop protection products when agricultural spray applications drift has economic and ecological consequences. Modification of the spray solution through tank additives and product formulation is an important drift reduction strategy that could mitigate these effects but has been studied less than most other strategies. Therefore, an experimental field study was conducted to evaluate spray drift resulting from agricultural ground applications of an insecticide formulated as a suspension concentrate (SC) and as a wettable powder (WP), with and without two adjuvants. Droplet sizes were also measured in a wind tunnel to determine if indirect methods could be substituted for field experimentation to quantify spray drift from these technologies. Results suggest that spray drift was reduced by 37% when comparing the SC to the WP formulation. As much as 63% drift reduction was achieved by incorporating certain spray adjuvants, but this depended on the formulation/adjuvant combination. The wind tunnel data for droplet spectra showed strong	Energy & Natural Resources 5 Healthy Living, Nutrition & Food Safety 7

		agreement with field deposition trends, suggesting that droplet statistics could be used to estimate drift reduction of spray solutions. These findings can be used to develop a classification scheme for formulated products and tank additives based on their potential for reducing spray drift. (Preftakes, et al. 2019) (Change in knowledge)	
88.	Development and Production of Ornamental Plants for Montana	Landscape plants provide a wide range of environmental, social and individual benefits, however the genetic diversity of the plants used to vegetate our urban landscapes is declining due to the continued loss of major tree species from problems such as the emerald ash borer, and the banning of non-native invasive species. This project is helping increase the diversity of plants available for use in urban settings through the development of sterile clones of four exotic, invasive species: European alder, Russian-olive, glossy buckthorn and Japanese spirea; and the production of semi-dwarf varieties of silver maple and Freeman maple, two tree species that are often not compatible with urban landscapes due to aggressive growth and large size. Two individuals of Frangula alnus were selected from the population in the field test plot. Cuttings taken from these individuals are under commercial evaluation for fertility, vigor, disease resistance, habit and overall ornamental appeal. Crosses were performed between tetraploid spirea resistant to spirea yellow leafspot virus and spirea leaf spot virus and ornamental diploid clones. Seed from these crosses will be germinated/grown in the greenhouse in late winter and planted into a field test plot in spring 2020. II. A second round of bud-grafting 'Autumn Blaze' freeman maple onto semi-dwarf silver maple rootstock was performed, resulting in a 70% success rate (14 of 20 grafts). These grafted trees will be planted in a test plot along with the two successful grafts obtained the previous year. (Change in knowledge)	Energy & Natural Resources 5
89.	Green Infrastructure Planning, Design, and Management for Student-Run Farms on College Campuses.	Over the last two decades, leveraging the landscape to perform ecological and cultural services has grown to be a valued approach for urban development. Now a more nuanced understanding is needed on the ways in which green infrastructure components and material details should be designed, constructed and managed in specific bioregional or land use	Energy & Natural Resources 5

		contexts. In addition, further understanding of people's perceptions of green infrastructure will improve project acceptance and impact. This project investigated three areas: how student farms can be designed to be high performing green infrastructure in the campus landscape; how people perceive green infrastructure design characteristics in the context of land regeneration and the semi-arid West, and how green infrastructure design strategies are applied in a land regeneration project to improve livability. The MAES researcher employed "grounded theory and content analysis to analyze 27 semistructured interviews with student farm personnel and direct field observations from 19 student farm sites at 12 public universities. The findings of this study suggest important considerations for site selection based on accessibility, appearance, and visibility. Onsite design recommendations for layout, spaces, and features are presented for six domains of the farm site. These findings illuminate how resilient student farm sites rely not only on appropriate biophysical conditions and production efficiencies, but also on physical spaces that stimulate social interaction and align with the broader campus context. These insights are most applicable to new or expanding student farms undergoing the master planning process. (VanWieren, 2018). (Change in knowledge)	
90.	Determining the Role of Viruses on Honeybee Health.	Honeybees are important pollinators of agricultural crops and plant species that enhance ecosystem biodiversity. High annual losses of US honeybee colonies (averaging 33% since 2006) have been associated with RNA viruses, but the mechanisms of honeybee host - virus interactions remain largely uncharacterized. The long-term goal of this research is to reduce honeybee colony losses caused by virus infections by advancing the epidemiologic and mechanistic understanding of the effects of viruses on bee health. To better understand the role of viruses in colony losses, we will longitudinally monitor honeybee colonies and examine the relationship between colony health and pathogen prevalence and abundance. At the individual bee level, virus infections can remain asymptomatic, cause paralysis, or result in death. These differential outcomes are largely dependent on host immune responses, yet the mechanisms of honeybee antiviral responses remain largely	Energy & Natural Resources 5

		uncharacterized. To elucidate the mechanisms of honeybee host antiviral defense, the MAES research team performed laboratory-based virus infection trials in individual bees and identify candidate honeybee antiviral defense genes using high throughput sequencing, determining the presence and abundance of pathogens. This data is coupled to colony health status (using colony population size as a proxy for colony health) to evaluate the impact of pathogens on colony health. Experiments were carried out in primary honeybee cells that were maintained in culture in the laboratory that validated the importance a gene (i.e., MF116383) that the research team determined was important to honeybee antiviral defense in individual bees. Experiments were carried out in laboratory-based studies in which honeybees were infected with a virus, the results indicate the importance of the heat shock response (a stress response pathway) in honeybee antiviral defense. The team advanced their ability to use primary honeybee cells for virus-infection studies; successfully culturing primary honeybee larval hemocytes and mixed cell populations from honeybee pupae. In cultured hemocytes Lake Sinai virus 2, a common honeybee infecting virus, exhibited modest replication within 2-3 days post-infection. (Change in knowledge)	
91.	Valley County MSUE Agriculture and Natural Resources Agent Builds Partnership to Support a Healthy and Thriving Bee Industry and Increase in Pollinator Plantings.	The Valley County MSUE Agriculture Agent supports commercial and hobbyists honey beekeepers. This program has been highly successful and greatly appreciated by beekeepers. Beekeepers have improved the survivorship of overwintering bees, advanced pest management, increased colony numbers, and forged positive relationships between hobbyists and commercial beekeepers. The program has also improved public awareness of honeybee importance and crop pollination. Extension has established strong collaboration with the US Army Corp of Engineers for pollinator habitat development and improvement through education regarding high quality forage plants, how to plant and maintain pollinator plant species, and best gardening practices to encourage pollinator visits. The MSUE Agent has been instrumental in recruiting volunteers from the Master Gardener program to help plant and maintain future pollinator gardens	Energy & Natural Resources 5

		around the Fort Peck Interpretive Center. (Change in knowledge. Change in action)	
92.	Lewis and Clark County MSUE Agent Builds Partnerships with the Montana Department of Agriculture and the Public to Train Beekeepers and the Public about Bee Care and the Importance of Pollinators.	This year the Lewis & Clark County Extension Office hosted two Montana Department of Agriculture beehives and one Extension beehive at the People's Garden at the Fairgrounds. These hives are used to educate youth and adults on beekeeping methods and allow exposure to equipment, techniques, and hands-on learning. The first workshop welcomed 26 youth and adults to a demonstration on preparing hives for winter using tar paper and the mountain camp method to feed the honeybees and keep them warm through the winter (Change in knowledge)	Energy & Natural Resources 5
93.	The role of geochemical forcing on the ecology, evolution and biodiversity of deeply-rooted thermophilic microorganisms.	The MAES researcher completed several studies focused on newly described thermophilic microbial lineages from Yellowstone National Park. These organisms root deeply in the tree of life and exhibit metabolisms that are often considered ancient and important in the origins of life. One of the new phylum level lineages comes from Fe-oxide mats (*Marsarchaeota*) and is important in low pH conditions. Novel members of the *Korarchaeota* were found to contain new pathways for methane metabolism. The metagenome collected to analyze the microbial community at Washburn hot spring was used in high-level journal articles related to methane cycling. (Change in knowledge)	Energy & Natural Resources 5
94.	Automating Simulation Model Generation from Conceptualizations of Linked Elemental Cycles in Biogeochemical Systems: A Constraint-based Modeling Approach.	The cycling of nutrients, carbon, and other elements in ecosystems is a primary means by which atmospheric, terrestrial, and aquatic ecosystems interact globally. Yet key cycles, such as the carbon, nitrogen, and oxygen cycles, do not occur in isolation, but rather, influence one another in complex ways. For instance, the presence of bioavailable forms of carbon and oxygen will influence the rates and mechanisms by which nitrogen is cycled in soils and aquatic systems. Similarly, nitrogen and oxygen availability affect carbon cycling, and carbon and nitrogen availability affect oxygen cycling. Understanding these cycles, and the interactions between them, is critical for to describe how ecosystem dynamics affect the productivity of forests, grasslands, agricultural lands, rivers, lakes, and oceans. Because of the inherent complexity of these cycles and the	Energy & Natural Resources 5

		interactions among them, computer simulation models are a necessary component of biogeochemical research. The MAES research team sought to create an algorithm that will automate the generation of computer code that will allow scientists to simulate the linked elemental cycling in ecosystems. This approach represents a leap forward in the ability to generate and apply simulation models that represent elemental cycling in ecosystems, which will facilitate research on improving our ability to manage soils to increase agricultural production and to manage water quality in stream, lakes, and coastal oceans. An improved capacity to simulate and predict how elemental cycles interact is essential for building the capacity to manage agricultural lands and understand the operation of the world's ecological systems. The team has identified appropriate software engineering principles to implement proposed improvements to the GANGSTA model generation software. They have completed an initial set of laboratory experiments to challenge predictions made by models generated by the GANGSTA system and compiled those results into a database. These accomplishments provide the necessary foundation for the next step in the research, which is to use the GANGSTA to create competing models and assess which of the models is best able to simulate the observed elemental cycling in the experimental systems. (Change in knowledge)	
95.	Nutrient Limitation and Cycling on a Greening Earth with Increasing CO2.	Nitrogen (N) is arguably the most limiting element for plant growth on Earth yet there remain critical uncertainties in our understanding of N limitation at the ecosystem scale and how N constraints to vegetation growth are changing in response to increases in C02 and warming. The MAES researcher investigated N constraints on biomass accumulation in tropical forests and the role of N fixation. Tropical forests are widely recognized as a critical part of the Earth-climate system and global water and biogeochemical cycles. Secondly, the researcher investigated the influence of climate change and increasing C02 on historical and future patterns of vegetative production in the Northern Great Plains of Montana. Grasslands are a common and important ecological feature of Montana landscapes, are critical to regional water and energy balance,	Energy & Natural Resources 5

		and may be highly sensitive to global change. The researcher combined decades of stem inventory data, in-situ measures of symbiotic N fixation, and simulations of N demand to evaluate demographic and biogeochemical controls on biomass dynamics in legume-rich lowland forests of Trinidad. The research found a net biomass accumulation and high rates of N fixation in these forests, regardless of the timing of selective timber harvests, including an old growth stand. The biomass accumulation was explained by growth of nonfixing trees, not N-fixing trees, but the total amount of symbiotic N fixation was sufficient to account for most of net above ground N demands, suggesting that N-fixers could contribute to the long-term carbon (C) sink in these forests via fertilizing non-fixers. Vegetation greenness has increased across much of the global land surface over the past four decades. This trend is projected to continue -particularly in northern latitudes - but future greening may be constrained by nutrient availability needed for plant C assimilation in response to CO2 enrichment (eCO2). The researcher documented significant greening over the past two decades with the highest proportional increases in net greening occurring in the driest and warmest areas. The simultaneous increase in greening and decline in foliar N across our study area points to increased N use efficiency (NUE) over the last two decades. However, our results suggest that plant NUE responses are likely insufficient to sustain observed greening trends in NGP grasslands. (Change in knowledge)	
96.	Genetic Engineering of Plant Oils of Industrial Applications.	Basic research will advance our understanding of biochemical and genetic mechanisms that govern the diversity of fatty acids in plant seed oils and guide effective engineering of oilseed crops for improved oil quality. This project will be conducted in camelina (*Camelina sativa*), an emerging crop in the Great Plains, and a potential dedicated industrial oilseed for the production of bio-based fuels and lubricants. Camelina is a low-input, drought tolerant oil crop that is not currently developed for food uses. Camelina has unparalleled potential among oilseed crops for the rapid engineering of multigene traits, due to the availability of a simple and robust genetic transformation protocol. The MAES research team has	Energy & Natural Resources 5

		developed a molecular mechanism of polyunsaturated fatty acid (e.g., linolenic acid) accumulation in seed. Decreasing saturated fatty acids may increase unsaturated (e.g., oleic acid) in camelina seed. In this study, saturated fatty acids were greatly. The total saturated fatty acid content was decreased by 35% from 14.6% to 9.4% of total fatty acids. This work demonstrates that the FATB genes in camelina can be effectively knocked down by an artificial microRNA targeting gene-specific sequences, thus provides an additional tool to improve seed oils for desired properties. Genetic factors controlling seed size in camelina. A major breeding objective for camelina is to increase seed size and oil content. Understanding the genetics behind variations of seed size and associated traits such as oil content would help breeders develop varieties of increased oil yield that are more robust, easier to plant and harvest, and better for oil processing. The results of this study are the first step to isolate genes controlling seed development and oil accumulation and to develop advanced varieties of camelina better adapted to modern agriculture by marker-assisted breeding. In addition, overexpression of miR167A (miR167OE) increased seed size. Expression levels of many genes were altered in miR167OE, including orthologs that have previously been identified to affect seed size in other plants. Most notably, genes for seed coat development such as suberin and lignin biosynthesis were down-regulated. This study provides valuable insights into the regulatory mechanism of fatty acid metabolism and seed size determination and suggests possible approaches to improve these important traits in camelina. (Change in knowledge)	
97.	MSUE Missoula County Provides Statewide, Regional, National, and International Leadership in Invasive Species, Supporting Research and Education; and Forging Partnerships at all Levels.	Invasive species include plants, animals, and pathogens that are non-native to local ecosystems and cause harm to natural and cultural resources, the economy, and human health. The MSUE Missoula County Agriculture and Natural Resources Agent leads a comprehensive set of partnerships and collaborations to operate a science-based, discovery, implementation, and education program to identify, prevent, eliminate, reduce, and mitigate the impacts of invasive species in Montana. To address this complex problem, the Governor's Office established the	Energy & Natural Resources 5 Integrated Pest Management 4

		Montana Invasive Species Advisory Council (MISAC) in 2015, led by one of the Missoula County Extension Office's key weed employees. The Council is a diverse group of scientists and resource managers charged with developing "a science-based, comprehensive program to identify, prevent, eliminate, reduce, and mitigate the impacts of invasive species in Montana." The Council began their work with a Statewide Assessment or inventory of the individuals, groups, and agencies working on invasive species, their management priorities, and an estimate of their expenditures in March of 2016. Major projects to improve our science in managing invasive species include: - A USDA/ARS Researcher has agreed to improve our knowledge on the management of leafy spurge. - The Montana Invasive Species Council organized a science advisory panel to address the approval and use of *Mogulones crucifer* to control houndstongue. The panel's recommendations include a) Develop consistent protocol for monitoring *M. crucifer* and non-targets. b) Develop mitigation strategies to follow science-based decisions where needed. c) Petition be developed and submitted to regulatory agencies for release of *M. crucifer* in the U.S. d) Fully utilize all new field and laboratory data that are available to support petition decisions being made based on the ecological host range of *M. crucifer* - MSUE Missoula County hosts the Montana Biocontrol Project Coordinator (funded cooperatively by several county, state, and federal units) has established the rust fungus at a number of Canada thistle sites and is evaluating results. - Funding from the Plant Protection Act and partner contributions has enabled the creation of a biocontrol monitoring project. Thirty-five transects were monitored during the 2019 growing season. - The Montana Biocontrol Project Coordinator, represented MSUE Missoula County and Montana at the International Biocontrol Symposium that was conducted in Engleberg, Switzerland. She presented a poster on Habitat Suitability for Biocontrol Agents in Montana.	

		- MSUE Missoula County organized and managed the boat check station at Clearwater Junction in cooperation and funding from Montana Fish, Wildlife, and Parks Department. Under leadership of Missoula County Weed District employees housed and supervised by MSUE Missoula County Extension, 20,880 boats were checked for invasive aquatic species. The Clearwater Watercraft Inspection Station had the greatest number of watercrafts of all the Montana inspection stations. And no invasive aquatic species were found. - The Montana Invasive Species Council was successful in securing $12 Million through the Montana Legislature for two years of prevention work. (Change in knowledge. Change in action)	
98.	Gallatin County MSUE Natural Resources Agent Helps Homeowners in Two Counties Manage their Wildfire Risk and Protect their Homes if Wildfire Arrives on their Property.	2019 was a big year for the MSU Extension Gallatin County Natural Resources Program. Over 53 landowners scattered between Gallatin and Park Counties engaged in MSU Extension's Wildfire Risk Reduction Cost-Share Reimbursement program. Landowners voluntarily signed up for the program and committed to reducing their wildfire risk through initial and ongoing vegetation management. Most property owners focused their efforts within the area 30' feet from structures and of ingress/egress routes of the properties. A few chose to engage in more "landscape scale" fuels reduction projects. General parameters followed by property owners were removing ladder fuels and limbing remaining trees to 1/3rd the tree height, and thinning trees to a spacing of 10'-15' between individual tree crowns or leaving small bunches of trees and maintaining a 20' spacing between bunches. This would help to keep fire activity on the ground rather than in tree canopies and would help to break up continuous fuel sources. Properties are now more defensible and accessible for responding fire crews and are able to survive a wildfire with limited damage. Benefits included forest and rangeland improvement, enhanced wildlife habitat, and improved aesthetics for property owners. Some landowners were initially caught off guard by how "open" their property became, they soon found their properties better prepared for wildfire and more accessible. In total, landowners will have completed over 230+ acres of wildfire risk reduction work on private property. This MSU Extension Program was	Energy & Natural Resources 5

		funded through three grants from the USDA Forest Service through the Montana Department of Natural Resources, Gallatin County and MSU Extension. (Change in knowledge)	
99.	MSUE 4-H Center for Youth Development Documents 4-H Members are more Civically-Minded after Participating in 4-H at any Age.	Youth engaged in their community is often claimed to be enhanced through 4-H involvement. Anecdotal evidence suggests that young people with a 4-H background participate in community service, are aware of community problems, and want to help solve community problems. To provide evidence of growth in citizenship skills resulting from 4-H experiences, enrolled 4-H members will be surveyed across Montana. Resulting data will be analyzed for statewide impact as well as made available for individual county use. Montana 4-H Center staff designed and provided surveys and data recording instruments to county Extension agents. Separate Citizenship Surveys for 3rd–6th graders and 7th–12th graders were conducted. 4-H volunteers will be asked to distribute, implement, and collect surveys within their clubs or projects. Email and social media were used to disseminate the surveys. Of the 4-H members responding to the 3rd-6th grade survey: Each statement shown was statistically significant between the pre and post responses. 1. I like helping people in my community, 47.41% indicated positive growth. 2. I have helped plan a community service project, 50.43% indicated positive growth. 3. I have led a community service project, 24.14% indicated positive growth. 4. I feel a part of my community, 24.14% indicated positive growth. 5. When I learn about a problem in the community, I look for ways to help, 46.55% indicated positive growth. 6. I can make a difference in my community, 45.47% indicated positive growth. 7. When I learn about a problem in another place, I look for ways to help, 39.61% indicated positive growth.	Youth and Family Development 6

		8. I care about my community, 23.71% indicated positive growth. Of the 4-H members responding to the 7th-12th grade survey: Each statement shown was statistically significant between the pre and post responses. 1. I like helping people in my community, 45.53% indicated positive growth. 2. I have met community leaders, 43.87% indicated positive growth. 3. I have helped plan a community service project, 50.31% indicated positive growth. 4. I have led a community service project, 35.34% indicated positive growth. 5. I feel a part of my community, 45.53% indicated positive growth. 6. When I learn about a problem in the community, I look for ways to help, 44.49% indicated positive growth. 7. I encourage others to volunteer in my community, 47.82% indicated positive growth. 8. I talk about needs in my community, 39.09% indicated positive growth. 9. I am inspired to volunteer in my community, 44.28% indicated positive growth. 10. I feel a responsibility to help in my community, 43.04% indicated positive growth. 11. I can make a difference in my community, 49.48% indicated positive growth. 12. When I learn about a problem somewhere else, I look for ways to help, 39.09% indicated positive growth. 13. I have learned skills while serving my community that will help me in the future, 52.39% indicated positive growth. 14. I pay attention to news events that affect my community, 42.00% indicated positive growth. 15. I talk to my friends about issues affecting my community, state, or world, 37.63% indicated positive growth.	

		16. I am aware of important needs in my community, 42.41% indicated positive growth. 17. After high school I will continue to work to better my community, 39.50% indicated positive growth. 18. I value learning about other cultures, 35.14% indicated positive growth. 19. I have learned about people who are different from me, 44.38% indicated positive growth. • "4-H Has taught me responsibility and showmanship." 10-year-old • "Kids learn life skills by leading hands on projects in areas like science, health, agriculture and civic engagement. 4-H helps us people grow confidence…" 12-year-old • "In the future, I think my 4-H experience will help me in many ways. It has helped me to mature, learn responsibility and learn the importance of being an active community member." 18-year-old • "I know that in the future I will be better prepared for difficult situations and problems because of the skills 4-H has taught me. 4-H will help me throughout the rest of my life, even in the moments I may not know that it will." 18-year-old (Change in knowledge. Change in action)	
100.	Fort Peck MSUE Develops Partnerships with Communities and Schools to Build Community Pride and Self-Accomplishment in American Indian Youth.	Working with tribal departments, schools, youth groups, and businesses helps identify where some outreach programs are needed. In several schools, art instruction isn't always able to focus time or money on fun aspects of learning. The MSUE Agent was able to supplement curriculum plans and activities for teachers in art, crafting, and hands-on activities. Some of the programs also centered on the Montana mandate of Indian Education for All. Arts and crafts projects have included making leather ornaments, bookmarks, or key rings. We were able to provide a robotics kit with support from the Gianforte Family Foundation to use in conjunction with STEM activities. In cooking and food preparation classes, we focus on simple snacks or discuss old tradition vs. new tradition. We	Youth and Family Development 6 Healthy Living, Nutrition & Food Safety 7 Community Development 8

		create sausage, jerky, summer sausage, and snack sticks in a completely hands-on environment meant to enhance student learning. Holiday-centered crafts are created for youth to bring to their families. All of these projects help to support family cohesiveness and invite children to communicate. They can articulate what they did, feel great pride in something accomplished, and inspire further learning or creativity. Life skills learning in a positive youth development setting has shown that hands-on learning experiences can make a positive impact on youth and those around them. (Change in knowledge)	
101.	Wheatland County MSUE Agent Partners with Local School to Reach Underserved Youth and Build Enthusiasm through the Youth Entrepreneurship Project.	The MSUE Agent recognized an opportunity to reach youth who were not currently engaged in other youth development programs and develop non-traditional 4-H programs that would meet their needs. To engage youth who like to think creatively and outside the box, the agent partnered with the Harlowton High School business teacher to create a Youth Entrepreneurship club. The Youth Entrepreneurship (YE) curriculum uses experiential learning models to create a fun, interactive space where youth are excited to engage. The teacher shared that youth who have never been passionate about anything were excited about the YE activities. The club was a safe place for youth to belong, where they were encouraged to think about problems differently.	Youth and Family Development 6 Community Development 8
102.	Flathead Indian Reservation MSUE FRTEP Agent Leads Youth Mentoring Program that Encourages Elementary Students to Successful Lives, Develops Leadership Skill in High School Mentors, and Strengthens Family Units.	Native American students make up the largest minority group in Montana—about 11 percent. Native students have the lowest high school graduation rate. Two major factors are lacking social and emotional skills. The Flathead Reservation Extension 4-H MSUE Agent began a mentoring program in 2012. During the past year, 30 K-7 mentees were paired with adult or high school student mentors for this year-long program. Mentors attend monthly trainings that help to support and build their skills in appropriate relationship building. Mentors meet weekly with their mentees for fun skill-building activities. A monthly 4-H club meeting is held in conjunction with a Family Night Out event. The program starts with mentees during after school hours, where they engage in 4-H Youth Development activities. When families arrive, everyone enjoys a complementary supper. Families participate in family strengthening	Youth and Family Development 6

		activities during this time. Activities include building trust, family support, kindness, community service, building positive family communication, working together, problem solving and strengthening family traditions. (Change in knowledge)	
103.	Toole County MSUE Family and Consumer Sciences Agent Builds Partnerships to Help Challenged Youth have the Confidence to Make Healthy Decisions, Reduce the Negative Influences of Peer, and Build Relationship with Caring Adults who are able to Provide Mentorship.	Toole County MSUE Family and Consumer Sciences Agent and Alliance for Youth collaborated to implement a youth camp for sixth to eighth graders from at-risk and income-challenged families to provide an overnight camping experience for youth that includes an educational component focusing on helping youth build skills around healthy choices. This year the first Health Rocks camp was held in early August at the Daryl Fenner 4-H Camp in Ferndale. Eighteen youth from Toole County attended. For most attendees, this was their first opportunity to attend a multi-day, overnight camp away from home. The youth experienced sleeping in cabins, campfires, hiking, swimming, boating and field trips during camp. According to pre- and post-evaluation results: • Before the program, four participants strongly agreed that they can avoid trouble by making good decisions, and after, this number rose to 12. • Before the program, six out of 17 participants said they did not know how to say no to peer pressure and after the program, 16 out of 17 participants said they knew how to say no to peer pressure. Youth developed caring relationships with each other and the adult chaperones who can have direct influence in their lives. Developing a relationship with a deputy sheriff and high school teacher will help guide these youth through their high school careers. Another benefit of the camp was that youth made friendships with others outside of their town and economic circles. (Change in knowledge)	Youth and Family Development 6 Healthy Living, Nutrition & Food Safety 7
104.	Broadwater County MSUE Agent Develops and New Community Organization to Support Pre-School Aged Children.	A couple of years ago, the MSUE Agent became involved in a community initiative to increase the quality and quantity of childcare providers in Broadwater County. This initiative developed a new community organization called the Broadwater Early Childhood Advocates (BECA). The mission of BECA is to be a supportive community resource, working with community partners for young children and their families. Projects include childcare, early childhood education, wellness, and family support. The	Youth and Family Development 6 Community Development 8

		agent was instrumental in developing the new organization and obtaining a fiscal sponsor as a 501(c)3. The first major project of BECA was to bring the Imagination Library to Broadwater County. The Imagination Library is a program facilitated by the Dolly Parton Foundation in partnership with a local organization. Every child who is enrolled in the program receives a free age appropriate book each month from birth until the age of 5. There are many research-based benefits to reading with young children. Studies have shown that reading to young children helps with essential brain development, improve kindergarten readiness and strengthen the community literacy level. The Dolly Parton Foundation covers some costs of the program, but it is the responsibility of the local community partner to fund the cost of books, postage and mailing which equals $25/child/year. With the agent in the lead, BECA raised over $6,000 for the program by the fall of 2019. In October, the program officially launched in Broadwater County and actively enrolling youth who received their first book in December.	
105.	Pondera County MSUE Agent Leads Innovative 4-H Project to Practice Conservation and Increase Pheasant Populations on the Rocky Mountain Front.	Eight 4-H members and three Cloverbuds took part in a brand-new project offered in Pondera County; raising and releasing ring-necked pheasants. Members bought 400 newly-hatched pheasant chicks from a local pheasant farm and raised them for release as part of Montana Fish, Wildlife, and Parks Upland Game Bird Enhancement Program. In recent years, upland game bird populations have struggled due to habitat decline and harsh winters. With this in mind, and some help from Montana FWP, the group picked three locations with prime pheasant habitat to be a new home for their birds. Throughout the winter, the group prepared to care for birds with project meetings to learn about the life of a pheasant in the wild and their habitat requirements. In June, the members picked up chicks and took them home. The youth spent the next 11-12 weeks caring for their birds. They fed, watered, and kept their chicks warm. They built pens and outfitted the birds with peepers to reduce pecking. Unfortunately, the 4-H members gained first-hand knowledge of predation when a weasel got into a pen and killed over 100 birds in one night. They carried on with the remaining pheasants. At the end of August,	Youth and Family Development 6 Energy & Natural Resources 5

		the members released 168 birds into the wild. This project was a broad learning opportunity for 4-H members. They learned the importance of conservation and that without appropriate habitat and food, their beloved birds wouldn't survive in the wild. It is also hoped that the pheasants these 4-H members released will boost wild populations of ring-necked pheasants in Pondera County. (Change in knowledge)	
106.	Glacier County MSUE Help Youth and Parents Learn and Understand the Beef Industry and Their Place in it.	Beef feeding and processing industries are very limited in Montana, and producers and 4-H youth have limited exposure to learn from the meat industry. The MSUE Agent in Glacier County was awarded a Montana 4-H Foundation grant. Thirteen 4-H members and 6 parents attended a June seminar and tour in Brooks, Alberta, Canada, to experience the beef feeding industry firsthand. They visited MCF Feedyards (63,000 head of cattle on feed that day), met with a feedlot nutritionist, and learned about beef processing from JBS Packing representatives. Prior to the tour, most members perceived technology in the feedlot industry as tractors, hay busters, and computers. In a post-evaluation, 4-Her's identified technology as feed ration formulations, electronic identification (EID) tags, laptops and scanners for EID tags, implants, and water sprinklers to control dust. Prior to the program, 80% of 4-Her's thought that anywhere from 11% to 99% of the beef animal was thrown out during processing. After the program, all of the 4-H members had a better understanding of animal byproducts and answered that less than 10% of the animal is thrown out. One member commented, "I learned that the highest priority in the packing plant is the animal's welfare so none of the things they do are painful or hurt the animal in any way." 4-Her's and parents who attended planned to change their pen layout to increase animal exercise, change feed rations, and keep better records. (Change in knowledge)	Youth and Family Development 6 Animal Sciences 1
107.	Flathead Indian Reservation MSUE Agent Helps Youth Improve Mental Health.	Youth Aware Mental Health (YAM) provides youth with better resiliency through education and discussion about mental health and the development of problem-solving skills and emotional intelligence. The intervention enhances students' ability to cope with stress and crisis and to seek professional help. A culturally appropriate adaptation of YAM to Montana was completed in the summer of 2016. In the last year, over 80	Youth and Family Development 6

		high school freshmen on the Flathead Indian Reservation participated in the YAM program. One student said, "...we got a chance to be educated about mental health and it was okay to feel certain emotions." (Change in knowledge)	
108.	Custer County MSUE Family and Consumer Sciences Agent Adjusts to Emerging Needs, Builds Partnerships, and Provided Leadership in Meeting the Educational Needs of the Community and Underserved Audiences.	Family and Consumer Science programming in Custer County continues to evolve as the needs in the community change, new county and statewide issues were identified. Pine Hills Correctional Facility, located in Miles City has been a youth facility since its inception, but it now also houses young men. Many of the men incarcerated there are parents. We know that a father's interaction with his children promotes healthy physical, emotional, social and spiritual development. Most of the men in Pine Hills have not grown up with a healthy role model for parenting. The agent taught a 12-week parenting class to 8 inmates at Pine Hills Correctional Facility. The curriculum, "Inside Out Dad" is design especially for incarcerated men. All 8 men were released shortly after the class was completed. (Change in knowledge)	Youth and Family Development 6 Healthy Living, Nutrition & Food Safety 7
109.	Judith Basin County MSUE Extension Agent Supports International 4-H Movement in South Korean	On September 20th, five delegates from the United States traveled from the US to South Korea for a Global Leadership Conference hosted by Korea 4-H. The purpose behind the event was to bring together 4-H members and leaders from many nations to network, build relationships, and create a global 4-H movement to educate and empower youth around the world. It was a privilege to be a part of the trip and be able to visit and network with 4-H members and leaders from over 20 countries. 4-H can really take you places! (Change in knowledge)	Youth and Family Development 6
110.	Butte-Silver Bow County MSUE Agent Leads Growth of 4-H in the Historic Mining Community.	MSUE's Butte-Silver Bow County 4-H has grown by 60% in the past 3 years, with a total of 87 enrolled members for the 2018-2019 4-H year and expanded the number of 4-H clubs. The MSUE Agent offered trainings for new families and volunteers entitled, "We Joined 4-H, Now What?" which was attended by 20 youth and 19 adults. During this workshop, members, parents, and volunteers learned about the 4-H program, roles, and the importance of communication to make a program successful for everyone involved. They were able to network with their club or project leaders, other members within the program, as well as have an opportunity to get	Youth and Family Development 6

		to know the 4-H Agent. Members were able to take on leadership roles this year as camp counselors at the Silver Bow County hosted Multi-County 4-H Camp. Camp leaders developed leadership workshops for 30 4-H members from around District 5. Members participated in communications workshops, STEM activities, cooking, healthy living activities, and recreation. There was record attendance, both with members and adult leaders, with 42 attendees representing 3 counties. With the growth of camp this year, more members are looking forward to becoming camp leaders and hosting their own workshops for next year. (Change in knowledge. Change in action.)	
111.	Lake County MSUE Partners with Local Stockmen's Association to Support 4-H Members Needed Support to Succeed in the Beef Breeding Project.	MSU Extension in Lake County partnered with Western Montana Stockmen's Association to establish a "Heifer Scholarship" Program. 4-H members ages 10 – 16 are eligible to apply for a yearly heifer supplied by the Stockmen's Association, to help these young people get involved in the cattle business. 4-H members enrolled in the Beef Breeding project are encouraged to apply, stating their background, available resources, intensions for continuing in the business, and identifying a mentor that can help them make it through the yearly cow production cycle. This program has proved to be a good partnership with MSU Extension Lake County, Western Montana Stockmen's Association, and the youth that are selected to receive heifers as a business scholarship. Nine 4-H members have earned the Heifer Scholarship to date. This partnership removes a financial barrier to youth want to participate in the Beef Breeding 4-H project.	Youth and Family Development 6 Animal Sciences 1
112.	Sanders County MSUE 4-H Agent Teaches Youth Diversity through an Interstate Exchange with and Urban Florida County.	In July 2019, Sanders County hosted their second 4-H interstate exchange with youth and adults from Duval County, FL (the city of Jacksonville). An interstate exchange program is an exciting opportunity for youth and adults to experience the geography, culture and heritage of a local community of 4-H youth and leaders with a common 4-H identity yet potentially different perspectives. For one week, youth learned about the Sanders County 4-H Program and the livelihoods of citizens throughout the county. Youth were guided through Ross Creek Cedars, drank huckleberry shakes in Trout Creek, visited the PPL Island Park, Fish Ladder, High Bridge, Old Jail Museum and went swimming and fishing at the Thompson Falls	Youth and Family Development 6

		State Park. They visited the National Bison Range, Glacier National Park, ate pizza at Ripples in Plains, and rafted down the Clark Fork River. Local 4-H Ambassadors presented the ins and outs of the 4-H program in Sanders County. Youth were surprised at the many differences in programs between the states such as, MT 4-H has a market project carcass evaluation. Families learned to be a host and created new and lasting friendships. Youth from Sanders County will be fundraising to travel to Duval County, FL in July of 2020. (Change in knowledge)	
113.	Educating and Empowering Aging Populations in Rural Montana about Opioid Misuse and Abuse.	Opioid misuse and abuse has increased at alarming rates across the U.S. for the past 10 years and is now a public health crisis that has reached epidemic rates (Rudd, Seth, David, & Scholl, 2016) that disproportionately affects rural populations (Mack, Jones, & Ballesteros, 2017). Montana has a rapidly growing aging population and the majority of the state is comprised of rural communities subject to many of these influences. These factors indicate a need to provide opioid misuse and abuse prevention and awareness, as well as proper storage and disposal of prescription medications. The MSUE team used a multi-phase approach to target the aging population in Montana by providing community awareness, education and strategies to prevent or reduce opioid misuse and abuse at the local level. Specifically, this project gained an understanding of community perceptions and knowledge-level related to opioid use by working with county Extension Faculty to coordinate forums in rural communities across Montana; used the information obtained from the forums to develop Montana-specific materials and resources to assist communities in raising awareness of opioid misuse and proper disposal of opioid-based medications; and collaborated with rural communities to initiate their own prescription medicine collection programs. Initial results have been disseminated to five of the six communities and is being shared with attendees of the community forums. A general results summary of aggregated data from all six communities will be shared with those communities, the public, media, etc. The MSUE team also partnered with the State Opioid Response and Tribal Opioid Response Teams that have greatly assisted in understanding the breadth of the opioid crisis in our	Healthy Living, Nutrition & Food Safety 7 Community Development 8

		state and provide support and guidance on needs of local communities as collaboration with others focused on the issue. Partnering with the State Opioid Response and Tribal Opioid Response Teams has enabled us to coordinate activities and refine our future prevention and education efforts and avoid duplication of efforts. Information obtained from the six forums and an on-line survey targeting 300 older Montanans was utilized develop Montana-specific materials and resources to assist communities in raising awareness of opioid misuse and proper disposal of opioid-based medications. Tribal partnerships led to revision of the target age to 45 and older to fit both tribal and non-tribal audiences. Additional feedback led to also including an intergenerational approach to reach younger people that are influenced by opioids. Four products have resulted from this preliminary work. Montana Suicide Wallet Cards - This wallet sized card was designed to graphically appeal to teenaged youth. The card offers five distress resources including the MT Crisis Line, Lifeline Chat, The National Suicide Prevention Hotline, the SAMHSA Opioids Hotline and a Montana 24 Hour Helpline (211). Distress Map entitled Responding to people under pressure under the big sky. These projects were done in collaboration with County agents and in conjunction with lateral Mental Health First Aid curriculum. Due to the expansive rural nature of Montana, the conversation at the community forums would often turn to ranchers that are in pain and are utilizing opioids for pain management. This conversation then led to topics of farm stress tying into drug and alcohol abuse, smoking, gambling, financial distress and stress, depression and finally suicide. Opioid Survey Report: Current perceptions, behaviors and prevention strategies of prescription opioid misuse: A Statewide Summary Report - This sixteen page data summary report offers Montana specific data, geo maps, charts and tables that are being circulated to strategic partners, collaborators, grant participants, community members and the general public. Call to Action: Since nearly half of respondents keep their unused prescription opioids in their home for at least 6 months, more education surrounding the benefits of proper disposal and ways to safely store prescription opioids is needed. Call to Action: If take-back boxes are	

		able to be placed securely, more take-back boxes need to be placed at pharmacies, medical clinics and hospitals around the state, in addition to those at law enforcement offices. Call to Action: Deterra® pouches need to be readily available (and explained) at pharmacies when Montanans go to pick up their prescriptions - survey data suggests that this dissemination method would yield the highest percentage of users. Call to Action: More education needs to be provided to Montana community members (including caregivers) surrounding safe household disposal options, including which medications can be flushed down the toilet. Call to Action: These results illustrate that a low percentage of Montanans are actively searching for information on prescription opioids. However, strategically placing education on social media, local radio and television, and in the hands of community members could prove effective in getting information into the hands of even those who are not actively seeking it. Call to Action: Data suggests that having educational materials available for parents to use to talk to their children about prescription opioids would be well received by Montanans. Opioid Fact Card - Both the survey report and feedback from the community forums indicated that the public needed general information the operational definition of an opioid. A handout was created to explain what opioids are, what opioid misuse is, and what are the signs of an opioid overdose (taken from Grocke, et al. 2019) (Change in knowledge)	
114.	MSUE Health and Wellness Specialist Leads a Diverse Team to Learn What Montanans Know about Opioid Medications and How they Manage their Prescribed Opioid Medications.	A survey of 379 Montana community members conducted in early 2019 revealed that 65% of respondents state that prescription opioid misuse is a problem in their community. Fifty-two percent of respondents state that they know someone who has misused prescription opioids to the extent that it has affected their life, and 21% either currently provide care to someone who has a prescription for opioids or had one in the past. However, underneath these disturbing statistics, lie some hopeful data. The first has to do with Montanans being willing to both safely store and dispose of their prescription opioids, if given the appropriate education and resources. While 28% of respondents state that they currently keep their unused prescription opioids in their home for 6 months to one year	Healthy Living, Nutrition & Food Safety 7

		after obtaining their prescription, 78% of Montanans said they would be likely to use a prescription take-back box if there was one available in the community, while 58% of respondents mentioned that they would utilize a disposal bag if one were made available to them. Additionally, although many Montanans report feeling undereducated about the dangers of prescription opioid use, 72% of Montanans reported that they would be likely to share information they had regarding the dangers of opioid use with their age-appropriate children. In terms of where respondents are likely to go for information, Montanans sited the Internet, health care providers, and their family and friends as resources to which they would turn. Such information and statistics should provide us confidence that with accessible prescription opioid storage and disposal resources as well as properly placed, widely disseminated educational materials, we can work together to help lower the rates of prescription opioid misuse throughout the state of Montana. (Change in knowledge)	
115.	MSUE's Food & Nutrition Specialist Documents the Statewide Impacts of the "Powerful Tools for Caregivers".	Montana's older population is one of the largest in the country. By 2025, Montana is presumed to rank between third and fifth in the nation in the percent of older adults 65+, which will account for at least 25 percent of the Montana population. Along with extended life expectancy comes a variety of chronic illnesses. Many older individuals live independently or with a spouse or partner, yet they often require a certain level of caregiving, and many Montanans will find themselves in the position of caring for elderly family members. Research studies find high rates of depression and anxiety among caregivers and increased vulnerability to health problems. Nationwide, AARP estimates that families provide 37 billion hours of care worth an estimated $470 billion to spouses, parents, disabled adult children and others. Montana has an estimated 118,000 unpaid caregivers providing 110 million hours of care to loved ones at a value of $1.4 billion (based on $12.97/hr.). Powerful Tools for Caregivers is an educational program for friends and relatives acting as caregivers for an adult with a chronic medical condition. In 2016 the program was modified to address care across the lifespan. According to the data, a before and after	Healthy Living, Nutrition & Food Safety 7

		assessment showed the following increases in what participants agreed they could do: 65% increase in those participants who agreed they are able to find positive ways to cope with the stress of caregiving. 64% increase in those participants who agreed they are able to take time for themselves without feeling guilty about it. 62% increase in those participants who agreed they are able to find community resources to help meet their needs as caregivers. 56% increase in those participants who reported feeling confident that they could ask for help with daily caregiving tasks such as shopping, cooking, cleaning, or transportation. 56% increase in those participants who agreed they could find ways to take care of their own health. 53% increase in those participants who agreed they could be more positive about their role as a caregiver. Participant Testimonials: "Learning how to take care of myself and learning how to let others know how I feel." "How, where, and when I need to get help and that I cannot do it all." "Confidence to continue caregiving. A healthy way to cope with everyday stress, excellent program!" (Change in knowledge)	
116.	Powder River County MSUE Family and Consumer Sciences Agent Builds Partnerships Across the State to Help Reduce Suicide and Opioid Abuse.	Montana State University is to be commended for responding to high suicide rates by the establishment of the Mental Health Center to research and provide resources to people in a state. Data has shown that suicide is the third leading cause of death in rural areas and affects people of all ages. The Powder River MSUE Family and Consumer Sciences Agent has been proactive in the area of mental health for youth and adults through the creation of the Youth Issues Coalition. With help from the Youth Issues Coalition, Youth Aware of Mental Health (YAM), THRIVE (computer-based, cognitive behavioral therapy program for adults in Montana), Mental Health First Aide; Youth Mental Health First Aide and musician Jason	Healthy Living, Nutrition & Food Safety 7 Community Development 8

		DeShaw, who's program demystifies the mental health stigma, have all been implemented in the schools and community. In addition, members of the Youth Issues Coalition hosted a facilitated discussion on opioid use in the community. The MSUE Agent has partnered with faculty at MSU to research the perception of the opioid use in the community; and to share thoughts and possible solutions that could address local issues. Participants included clergy, school counselors, law enforcement, concerned citizens, and medical personnel. Resources important to people living in rural areas have been developed and disseminated, including the publication "Responding to people under pressure under the big sky." The publication is valuable in helping people recognize warning signs of those in distress and determining a course of action. (Change in knowledge)	
117.	MSUE Healthy and Wellness Specialist Helps Montanans Increase Mental Wellness.	Numerous research points to the fact that MT has the highest suicide rate of any state. While this rate is caused by a multitude of factors, we also know through Needs Assessment data that Montana community members are in need of stress prevention resources and coping mechanisms to keep not only suicidality, but stress, depression and anxiety at bay. Also, this initiative indirectly helps to reduce the risk of suicidality and other adverse health issues that result as a consequence of high levels of chronic stress. This initiative involved creating three different mindfulness presentations for three distinct audiences: youth, community members, and scientists. Additionally, mindfulness practice sessions were recorded and disseminated to all Extension staff and faculty. Mindfulness resources were also published on the MSU Health and Wellness website. One high school teacher said "First and foremost, thanks for facilitating the Mindfulness presentation at [our school]. I think it was a huge success. My principal agrees. After chatting with lots of kids on Wednesday, Thursday and Friday, I noticed a couple of interesting things- * most kids found the presentation relaxing, about 2/3 said they might try it in the future, 1 or 2 in each class said they already did something like this, they were impressed that famous sports people/musicians/actresses practice this regularly, about half said they are having trouble sleeping from time to time & the juniors and seniors were the most vocal in saying	Healthy Living, Nutrition & Food Safety 7

		that they are having trouble managing stress and need strategies. Exposing all these students to mindfulness planted so many important seeds-- even for those who didn't buy in at the time. Thank you thank you!!" (Change in knowledge)	
118.	MSUE Health and Wellness Specialist Leads New Effort to Help Montana's Rural and Agricultural Communities Address Mental Wellness without Stigma.	The amount of information regarding to farm/ranch stress is very limited in Montana, the MSUE Specialist secured grant funding to form an advisory board (comprised of members from FSA, Farm Bureau, DPHHS, County Commissioners, and farmers and ranchers) to assist MSUE in creating the first statewide online clearinghouse of farm/ranch stress prevention and management resources. One of the first products of this new effort is a publication that serves as an action plan for people in distress. A reader can follow the steps in the publication and is guided to the appropriate resources either in MT or nationally. One MSUE Agent commented "Just a note to thank you and tell you how impressed I am with … 'Responding to people under pressure under the Big Sky'. The information is excellent and provided in a very usable context. I also love the quote, 'sometime [sic] you need help, sometimes you are the one that can help.' I think this helps diffuse the stigma surrounding mental health in rural areas…we need to recognize that we are all vulnerable." (Change in knowledge)	Healthy Living, Nutrition & Food Safety 7
119.	The Ravalli County MSUE Family and Consumer Sciences Agent Develops Innovative Partnerships that Improve Physical and Mental Health.	The MSUE Family and Consumer Sciences Agent, in partnership with MSU College of Nursing internship program, developed a winter wellness program to encourage Ravalli County residents to engage in physical activity during the cold, dark months from November 15-February 15. Participants who engaged in at least 10 minutes of daily activity could log their efforts and enter into a drawing to win prizes. WINter Wellness is the fourth health-incentive challenge offered by MSU Extension in the past three years. During this challenge, 211 adults from every community in the county logged over 4,192 entries of physical activity during this three-month challenge. Participants reported the following impacts: • 30% improved mental health • 32% increased physical activity • 31% increased motivation to move due to this program	Healthy Living, Nutrition & Food Safety 7

		• 8% increase in social ties to the community A Hamilton resident shared, "I will continue with my indoor planks, squats, etc. and walking down the hill and back up again to the mailbox. Your program has helped me to be stronger because it has given me incentive to keep up daily exercise." Partnerships are the key to creating community change through collaboration. This last year, MSU Extension partnered with Rocky Mountain Laboratories (RML) to offer an educational speaker series focusing on mental health, coined M.I.K.A. (Mental Illness Knowledge and Awareness). RML is a part of the National Institute of Allergy and Infectious Diseases (NIAID) and the National Institutes of Health (NIH). This past year, RML invited expert speakers to talk about research in mental illness and related topics, which aligned with their role of educating the community about science and public health. Mental health and illness potentially impacts every facet of a community. The attendance at the speaker series spurred MSU Extension and RML to offer community discussions surrounding mental illness. Together, community members, agencies and organizations have generated a prioritized list of action items to create community impact related to mental health. MSU Extension now sends a monthly update with the efforts of the community discussions, upcoming trainings and educational articles focusing on mental health to over 400 individuals in Ravalli County and throughout the nation. (Change in knowledge)	
120.	Hill County MSUE Family and Consumer Sciences Agent Implements a Robust Partnerships and Programs the Improve Healthy Living.	The MSUE Family and Consumer Sciences Agent was certified to teach Mental Health First Aid (MHFA) to adults in Montana and Youth Aware of Mental Health (YAM) to teens to increase awareness of mental health and decrease the stigma in talking about mental health illnesses. The MSUE Agent was able to collaborate with Havre High School and taught YAM, a 5-week session on mental health to 326 youth. The sessions included information on mental health symptoms and warning signs, including suicide. Teens also role-played situations that will better prepare them to deal with problems in the future. This evidence-based curriculum has shown a decrease in suicidal thoughts and increase mental health awareness.	Healthy Living, Nutrition & Food Safety 7

		Forging a new partnership with the Hill County Health Department and the Early Childhood Investment Team of Hill County resulted in Cooking with Kids. Dining with Diabetes was a pilot program in Havre with the collaboration of Bullhook Community Health Center. Evaluation results indicate that: 88% of participants reported they will cook more at home using recipes provided by the classes and 63% check their feet daily. The Agent also continued to teach vital programming in the areas of food safety, like the ServSafe Food Handler Class. One hundred and eighty-nine Hill County and Rocky Boy residents were certified as Food Handlers in 2019. (Change in knowledge)	
121.	Healthy Living, Nutrition & Food Safety	The MSUE Agent partnered Butte Cares to bring two courses of Adult Mental Health First Aid to Butte, training 40 members of the community. During the course, participants learned how to recognize the signs and symptoms of common mental health disorders. After taking the course, one participant said, "It was helpful in thinking through how to address situations with people who may be dealing with mental health illness". Participants were given scenarios to work through including helpful things to say, how to listen nonjudgmentally, and what types of help are available. Another participant added, "The course built confidence to ask the hard questions". By reducing the stigma, more people will feel comfortable seeking help for mental illness and reduce the number of attempted and completed suicides in our community. (Change in knowledge)	Healthy Living, Nutrition & Food Safety 7
122.	Richland County MSUE Family and Consumer Sciences Agent Helps Community Members Help those who are Considering Suicide.	In the state of Montana, one person dies by suicide every 33 hours, the highest suicide rate in the Nation. QPR is a suicide prevention training that allows everyone to develop skills to aid in a suicide crisis. QPR stands for Question, Persuade, and Refer and walks a person through 3 steps; asking the question, persuading a person who is suicidal to stay alive and referring them to professional help, which will aid in saving a life from suicide. The training is provided by a certified instructor, is an hour long and arms people with tools to help in their own community. One adult class participant said "QPR is a great tool to have. It allows the everyday person to help someone in need." One youth who has taken the class has	Healthy Living, Nutrition & Food Safety 7 Youth and Family Development 6

		taken the message of saving lives to heart and has created a self-determined project in 4-H that allows her to educate others about suicide prevention. Through this training, Montana community members are learning skills to help save lives. (Change in knowledge)	
123.	Teton County MSUE Family and Consumer Sciences Agent Develops a Comprehensive Mental Health Education Program to Reach the Youth and Adults of the County.	Mental health was one of the top three concerns identified in Teton County's 2017 Community Health Needs Assessment and Improvement Plan. Depression, anxiety, and stress were rated top mental health issues in Teton County. MSU Extension is meeting needs in Teton County through a variety of efforts. The Youth Aware of Mental Health (YAM) program reached 79 high school students in Teton County in 2018-19 and was offered to every ninth-grade student in Teton County. The program includes five sessions with students learning about mental health, coping skills, depression, suicide, and how to seek professional help. The program teaches students how to notice signs of mental health challenges in others and gives them a chance to practice approaching someone with concern about their wellbeing. Three months after participating in YAM, students report an increase in general mental health knowledge, significant decrease in depressive symptoms and a trending decrease in anxiety symptoms. Almost half of students reported they would seek help from school staff for assistance with feelings of suicide and 79% said they would seek help for depression. Montana ranks high among states on mental health disorder prevalence and low on access to mental health care. It has the highest suicide rate in the nation. Of Montana's 56 counties, 10 are classified as rural and 45 as frontier, accentuating distance challenges in accessing care. THRIVE online cognitive behavior therapy, a randomized clinical controlled trial from the MSU Center for Mental Health Research and Recovery, was promoted. The modules include training in assertive communication, constructive thinking and rewarding activities. More than 300 brochures on the program were distributed by MSU Extension in Teton County. In response to mental health issues in the agriculture sector, the MSUE Family and Consumer Sciences Agent taught a section of the Cropping Seminar in Teton County called, "Ag Under Pressure." Producers had the choice to stay for the presentation or leave for lunch	Healthy Living, Nutrition & Food Safety 7

		early and 90% stayed. Many sought additional resources directly following the program. (Change in knowledge. Change in action)	
124.	Wibaux County, Health Fair	The 31st anniversary of the Wibaux Health Fair "Keep Your Eyes on the Prize, Not the Obstacles" was open for business before the sun came up. The March 7 Health Fair opened its doors to over 550 youth and adults and 20 organizations exhibiting their health-related services. Youth enjoy the hands-on booths and picking up a snack or a free pencil. With an emphasis on prevention and healthy lifestyles, the Health Fair is sponsored by MSUE Wibaux County. Healthcare in Wibaux consists of a county-owned clinic staffed two days a week by Glendive Medical Center, and two days a week by Fallon Medical Complex. Nutrition and health education are essential components needed to emphasize the importance of developing healthy lifestyles. Routine medical examinations also play an important role in prevention, as well as early detection. The Health Fair saves community members thousands of dollars in health care costs. It has also saved the lives of those who have been referred to their primary care physician due to an abnormal blood profile or other the results of other screening tests provided at the Health Fair. (Change in knowledge)	Healthy Living, Nutrition & Food Safety 7 Community Development 8
125.	MSUE's Food & Nutrition and Health & Wellness Specialists Strengthen MSUE Agents' Evaluation and Understanding of the Learning They Support in Their Food, Nutrition, and Wellness Programming.	MSUE's Food & Nutrition and Health & Wellness Specialists developed and implemented a new evaluation initiative for all extension programming around the state that encompasses both health and wellness & food and nutrition content. This initiative came as a direct result of a face-to-face needs assess that included trips around the State. They learned that a primary concern of Extension agents was that they did not feel comfortable evaluating their programming successes and found it difficult to report to their county commissioners. Based on that feedback, they started processing all evaluation forms at MSU, and after analysis, sent agents summative statements that they can use for both their reporting and to disseminate to county commissioners and other interested stakeholders.	Healthy Living, Nutrition & Food Safety 7

		We were able to collect 967 responses from all 56 counties and over 17 tribal affiliations represented in addition to representation from both Extension and non-Extension participants, lower income participants, urban and rural participants etc. Overall Food and Nutrition class information (includes Dining With Diabetes and Food Preservation courses): 26 classes were taught in 2019 (8 of those were DWD) 216 collected survey responses from 11 agents across 10 counties (does not include DWD sites) 254 total participants (91 of these were from DWD classes) Data results After completing the class, positive behavior trends in at least 75% of participants were seen and participants are now planning to try or currently trying to... Choose a variety of protein options during the week (100%) Wash hands with soap and running water before preparing foods (100%) Eat 3-5 fruits and vegetables a day (95%) Cook or prepare most meals at home (93%) Eating more whole grains (90%) Choose beverages with less sugar (88%) Follow food safety guidelines (88%) Use the nutritional facts on food labels to make choices when selecting foods (75%) Because they participated: 100% of the participants learned more about how to read and understand food labels 96% of the participants learned how to prepare foods using a new technique or tool 96% of the participants learned recipes and/or meal ideas that align with the MyPlate guidelines	

		96% of the participants learned strategies to modify or substitute foods to make their meals healthier 92% of the participants learned strategies to stretch their food dollars 88% of the participants learned who to safely clean, prepare, and store foods eaten at home (Change in knowledge)	
126.	MSUE Statewide Nutrition Education Program Partners with EFNEP to in Improve Healthy Living Choices in Adults and Children.	The Expanded Food and Nutrition Education Program (EFNEP) in Montana assists low-income families, particularly those with young children, to address economic, obesity, and food insecurity challenges that hinder the health and well-being of its population. Educators across the state provide a series of nutrition education classes to youth in 1st, 3rd, and 5th grade classrooms, and also provide a series of Eating Smart Being Active classes to adults. A summer youth program is also offered for 3rd-6th grade students. Both youth and adult classes utilize a pre and post program evaluation that includes demographic data and a behavior checklist. Adult participants also complete a pre and post program 24-hour dietary recall to measure changes in diet. Specific Behaviors Improved (by Adult EFNEP Participants) (Percent of adults who made improvements in the following practices pre to post) 50% Eat vegetables more often 48% Eat fruit more often 49% Eat dark green vegetables more often 42% Drink regular soda less often 35% Cook dinner at home more times per week 53% Exercise for at least 30 min more days per week 50% Made small changes to be active more often 46% Thaw frozen food at room temp less often 22% Wash hands more often before preparing food 38% Have enough money for food more often 53% Plan meals before shopping more often 45% Compare food prices more often	Healthy Living, Nutrition & Food Safety 7

		Specific Behaviors Improved (by Youth EFNEP Participants) (Percent of youth who made improvements in the following practices pre to post) 82% of children improved their ability to choose foods according to MyPlate or their knowledge of healthy foods. 34% of children improved their knowledge of physical activity or physical activity practices 52% of children improved their knowledge of food safety or use safe food handling practices more often (Change in knowledge. Change in action)	
127.	MSUE Statewide Nutrition Education Program Partners with SNAP and Montana Department Public Health and Human Services to in Improve Healthy Living Choices in Adults and Children	SNAP-Ed educators across the state provide a series of nutrition education classes to youth in 1st, 3rd, and 5th grade classrooms, and also provide a series of Eating Smart Being Active classes to adults. A one-time adult class is also offered. Both youth and adult classes utilize a pre and post program evaluation that includes demographic data and a behavior checklist. Specific Behaviors Improved (by Adult SNAP-Ed Participants) (Percent of adults who made improvements in the following practices pre to post) 48% Eat vegetables more often 47% Eat fruit more often 45% Eat dark green vegetables more often 19% Drink regular soda less often 32% Cook dinner at home more times per week 36% Exercise for at least 30 min more days per week 36% Made small changes to be active more often 40% Thaw frozen food at room temp less often 21% Wash hands more often before preparing food 24% Have enough money for food more often 41% Plan meals before shopping more often 36% Compare food prices more often Specific Behaviors Improved (by Youth SNAP-Ed Participants) (Percent of youth who made improvements in the following practices pre to post) Children	Healthy Living, Nutrition & Food Safety 7

		84% of children improved their ability to choose foods according to MyPlate or knowledge of healthy foods. 39% of children improved their knowledge of physical activity or physical activity practices 56% of children improved their knowledge of food safety or use safe food handling practices more often (Change in knowledge. Change in action)	
128.	MSUE's Food & Nutrition Specialist Strengthens Educational Nutrition Programming Across Montana and Documents the Positive Changes in Montanan's Lives.	About 77,000 Montana adults currently are diagnosed with diabetes. The percentage of Montana adults with diagnosed diabetes increased from 2.8% in 1990 to 9.3% in 2018. In 2017, 7.4% of Montana adults reported having prediabetes. In previous years, MSU Extension had successfully offered Diabetes Education Empowerment Program in communities across the state, but funding and statewide support completed in 2019. Dining with Diabetes is a national Extension program aimed to assist participants with type 2 diabetes or pre-diabetes and their families to understand diabetes basics, cooking strategies helpful for diabetes management, and helping participants to connect with local medical professionals. Eight Extension Agents across Montana taught a total of nine Dining with Diabetes classes in 2019. A total of 91 rural Montana residence participated. Behavior change Positive behavior trends were seen in the participants who were not already engaging in the following behavior, 96% are planning to try or are currently trying to eat 3-5 fruits and vegetables a day and cook/prepare most of their meals at home. 93% are planning to try or are currently trying to use "Nutritional Facts" on food labels to make healthier food choices. 88% are planning to try or are currently trying to choose beverages with less sugar. 93% of participants are eating smaller portions 89% are cooking more meals at home and using recipes from the class when planning meals.	Healthy Living, Nutrition & Food Safety 7

		40% of participants are partaking in physical activity (such as walking) on a daily basis. Participants reported engaging in the following behaviors at least four times in the past week, resulting in 83% reviewing food labels before eating 72% considering portion sizes 63% exercising for 20-minutes or more 57% checking their feet 47% eating a variety of fruits and vegetables. Acquired knowledge 100% of participants reported learning how to read and understand food labels and how to choose recipes that align with the MyPlate guidelines. 98% walked away with strategies on how to modify or substitute foods to make their meals healthier. Attitudes about diabetes**:** 97% agree that their actions can make a positive difference for them or someone they care for, and view diabetes as a serious condition, even when you're feeling fine. 76% report feeling confident that they can keep their diabetes under control and/or help someone else. Testimonials: "I really enjoyed this class and would love to attend another." **"**I'm more aware of food labels and am paying much more attention to them." "The 'trick' to reading labels was very helpful." (Change in knowledge. Change in action)	
129.	Big Horn County MSUE Family and Consumer Sciences Agent Leads Efforts to Improve Healthy Living.	Dining with Diabetes focuses on helping individuals manage diabetes through diet, medication and exercise, and was brought to Big Horn County as a pilot program in 2019. The initial class included 16 participants and resulted in the formation of a Diabetic Support Group. The group	Healthy Living, Nutrition & Food Safety 7

		meets quarterly to enjoy a diabetic-friendly meal, network with other diabetics and listen to guest speakers. Since the original class in January 2019, another class was held in the fall and plans are underway for more classes in 2020. Results showed 100% of participants learned to read and understand food labels, to modify or substitute ingredients for making healthier meals, and to make meals align with MyPlate guidelines. Participants also reported positive behavior trends towards eating more fruits and vegetables, drinking less sugary drinks, and cooking more at home. Participants reported leaving the course feeling they can make a positive impact on themselves or others and 73% feel confident they could take the knowledge learned from the class and use it to stay in control of their own diabetes or help someone else. StrongPeople Strength Training in Big Horn County continues to grow as part of a first ever Nationwide Random Control Trial. Positive impacts were reported by 55 participants in four areas: • Physically, 90% of participants showed increased strength, balance, stamina, and the ability to move freely and easily. • Socially, 82% of participants increased community ties. • Mentally, 55% of participants reported a decrease in both stress and anxiety. • 61% reported significant increases in sleep, with 53% reporting decreased chronic pain. And as a testament to the benefits of the program, 98% intend to engage in similar exercise routines outside of StrongPeople Strength Training, while 88% intend to maintain friendships made during the program. (Change in action)	
130.	Valley County MSUE Family and Consumer Sciences Agent Helps Empower People Impacted by Diabetes to Improve their Health.	Diabetes is a very serious and costly disease, but research has shown that those who learn to manage their blood glucose (sugar) levels, eat healthy, and exercise regularly can lower their risk of complications and lead a healthier and more productive life. Participants in the Dining with Diabetes program learned how to prepare healthy, simple meals that taste good and fit into a diabetic diet. They also learned current information on	Healthy Living, Nutrition & Food Safety 7

		nutrition, meal planning, and exercise, as well as how to understand important diabetes-related medical tests. • 100% of the participants learning how to read and understand food labels, learning how to modify or substitute ingredients to make healthier meals, and learning how to make meals align with the MyPlate guidelines. • 100% of the participants reporting that they know which foods raises blood sugar levels the most • 88% of the participants know the Idaho Plate guidelines for how many non-starchy vegetables you should put on your plate. • 100% of the participants reported positive behavior trends towards eating more fruits and vegetables and reading the food labels • 89% are drinking less sugary drinks and cooking more at home. • 44% of the participants reporting that they are checking their feet daily. • 100% of the participants reported that they can make a positive impact in their own and others' lives and feel confident they use what they learned to stay in control of their own diabetes or help someone else. (Change in knowledge. Change in action)	
131.	Richland County MSUE Family and Consumer Sciences Agent Helps Residents Improve Health.	In Richland County, a variety of programs and classes related to health and wellness were offered. The Dining with Diabetes program resulted in 88% of the participants indicating they left the class feeling they could make a positive impact on themselves and others; in addition, 57% of the participants learned what food would raise blood sugar. After attending the Dining with Diabetes program, one Richland County resident said, "I enjoyed the class, and I feel that I learned a lot of valuable information that I can apply to my life and also share with others." Strong People classes were taught in Sidney, Fairview, and Savage MT. One Richland County Resident quoted the most important thing they gained from the Strong People program was "Physical strength and improved balance." An increase in community ties was reported by 80% of participants. All three classes/programs have had a positive impact on the residents of Richland County. (Change in knowledge)	Healthy Living, Nutrition & Food Safety 7

132.	Powder River County MSUE Family and Consumer Sciences Agent Helps Communities Improve Health and Healthy Living Habits.	Montana's county health rankings in 2018 placed Powder River County 28th out of 47 how long they live and how healthy they feel. Challenges included physical activity, alcohol use, and health care access. A 2015 regional needs assessment indicated that mental health and tobacco use were top community health needs. MSU Extension used this information to help build a healthier community. "Make the Healthy Choice the Easy Choice" The Montana Foundation's Arthritis Exercise Program and MSU Extension's Strong Women program improved the health of 36 Powder River County residents. Participants reported: • 75% Increase in strength, balance, and stamina • 65% Increase in the ability to move freely and easily • 25% Increase in community ties and friendships • 75% feel less anxious • 50% have less chronic pain • 75% feel less stressed • 100% intend to maintain friendships They reported that they: • Exercise regularly at home • Have and enjoy friendships and exercising with others • Quit taking a pain pill • Are more active and health is improved • Recognize the importance of exercise on overall health, not just the heart • Use the health education information Tai Ji Quan Moving for Better Balance (TJQMBB) classes began in June with 20 participants. They improved their balance in the program designed to also prevent falls. Participants commented: "It's physically active learning with a body awareness sensory phenomenon"; and "It's helping me with my balance." (Change in knowledge. Change in action)	Healthy Living, Nutrition & Food Safety 7

133.	MSUE's Health & Wellness Specialist Leads Multi-County Research with Cornell, Documents Positive Changes in Montanan's Lives Through Strong People® Exercise Program.	Strong People® is an evidence-based 12-week program provided by MSUE that helps participants increase their joint flexibility, muscle strength, balance, and overall well-being. 315 Montanans participated in a Strong People class in 2019 in the following locations: Thompson Falls, Choteau, Fort Benton, Havre, Glasgow, Fairview, Wibaux, Broadus, Hardin, Shepherd, Laurel, Bozeman, Miles City, Harlowton, and Two Dot Montana. Of those that participated in a 2019 Strong People program: • 95% felt stronger • 89% improved balance • 85% increased stamina • 85% moved more free & easy • 83% strenghened social ties • 77% felt less stressed • 76% felt less anxious • 71% slept better 94% of participants intend to engage in similar physical activity routines outside of class. Prior to participation, 9% of participants reported meeting the 2018 Physical Activity Guidelines. Upon completion, 18% of participants reported meeting the 2018 Physical Activity Guidelines. https://msuextension.org/wellness/strong_people_summary_2019.html (Change in knowledge. Change in Action)	Healthy Living, Nutrition & Food Safety 7
134.	Chouteau and Teton Counties MSUE Family and Consumer Sciences Agents Collaborates with Strong People® Strength Training Research Project, Improving the Health of Participants.	Teton County was one of six locations in Montana selected to participate in an exciting collaborative research study, Strong People Strength Training Program: A Community Based Randomized Trial. In this study, we are examining the effects of a twice-weekly strength training program on the health, including heart disease and diabetes, as well as the functional fitness of midlife and older adults. The MSUE Agent screened 50 people who were interested in participating in the study, with 32 ultimately qualifying. The agent is leading a research session, and because of ample interest, opened a non-research section of the class. In addition to	Healthy Living, Nutrition & Food Safety 7

		strength training, the agent incorporates nutritional tips and Extension extras, such as financial management, technology tips, prevention of falls, and home maintenance for older adults. Participants in classes have said, "The Strong People class allowed me to have the stamina to walk several miles on a charity walk." "I noticed a real difference shipping calves this year, even though I was slogging through mud and snow. I wasn't as tired or sore at the end of the day. I know it is because of the Strong People Class." "I had only been doing Strong People classes for a few weeks when I went hiking with my family. I noticed a distinct difference and my balance was tremendously better." (Change in knowledge)	
135.	Yellowstone County, MSUE Agents Respond to Emergency Drinking Water Orders to Complement the Water and Sewer District Efforts to Ensure Safe Drinking Water for Residents.	In July 2019, Worden and Ballantine town residents were given strict orders to halt infant tap water consumption due to high nitrate levels tested in the water. The issue expanded after coliforms were detected in raw water samples, and surface water was confirmed as the contamination source. MSU Extension in Yellowstone County recognized an immediate community need and complemented the efforts of the water systems teams, they partnered with the MSUE Water Quality (MSUEWQ), funded by both MSUE and MAES. Well Educated program. Many private well owners took advantage of services offered through Extension. Together, MSUE distributed over 170 tests kits and increased water quality awareness throughout the Yellowstone Valley. Through the collaborative efforts, private well owners have tested their wells at a lower cost and have also educated themselves on their own water quality. Educating well owners decreased the risk of water born illnesses, nitrate-related issues and increased awareness regarding what to test, how to treat wells, and the importance of regular maintenance. Through these local efforts these opportunities expanded throughout the county courtesy of MSU Extension resources. (Change in knowledge)	Healthy Living, Nutrition & Food Safety 7 Energy & Natural Resources 5
136.	MSUE Agents from Across Montana Partner with the Governor's Office of Economic Development and the Montana Community Foundation to	All across Montana, rural communities have experienced declining population trends, young people have gone off to college and never come back. A group of MSU Extension Agents noticed increasing efforts by organizations that serve rural areas to revitalize or try and rebuild the communities. It became apparent these organizations did not always know	Community Development 8

	Change the Narrative of Montana's Changing Rural Communities.	of each other or their efforts. After many planning and brainstorming sessions, Extension partnered with the Montana Community Foundation and the Governor's Office of Economic Development to host the "Reimagining Rural Conference," focusing on leadership development. Over 100 people attended the day-long conference, which hosted keynote speaker Ben Winchester, from the University of Minnesota Extension Center for Community Vitality, and several small group round-table discussions. Participants learned about "brain gain" and changing their own personal narrative about rural communities. Many times, the narrative is negative, focusing on what has been "lost," or what isn't the same. By focusing on positive attributes of the town and area around it, people that may have moved in, or are interested in these areas are met with a more inviting tone. Many attendees said they would change their personal narrative to be more positive when referring to these rural areas. (Change in knowledge)	
137.	Park County MSUE Community and Economic Development Agent Builds Leaders and Strengthens Community Commitment and Service.	The MSUE Community and Economic Development Agent launched the sixth Leadership 49 class; an eight-month leadership program designed to develop empowered and engaged citizens that will strengthen and connect the communities of Park County. Comprised of monthly day-long sessions, community-based experiences, and a group project, participants develop leadership skills, increase their knowledge about challenges and opportunities, and network with community groups, leaders, businesses, elected officials, and others. Upon graduation in the spring of 2020, the participants will join a group of 80 alumni actively working to make Park County a better place to live. One alumna said, "This experience has enabled me to broaden and deepen my connections with members of the community and my knowledge of Park County. It was an amazing experience that equipped me with the tools needed for personal and professional development." Community support of the program continues to grow, with 25 sponsors. Many supporters are alumni of the program and eagerly commit to sponsoring to develop leaders across Park County. Leadership 49 has become a core program of MSU Park County Extension and continues to grow and increase its impact. (Change in knowledge)	Community Development 8

138.	Wheatland County MSUE Agent Leads Citizens to Develop a Two-County Year-Long Interactive Leadership Development Series.	One out of every 13 people in Wheatland and Golden Valley Counties needs to serve in a leadership role to fill elected and board positions. To help community members feel more comfortable and confident in filling leadership roles, the Wheatland County MSUE Agent offered the first class of Leadership 44/53 for residents of Wheatland and Golden Valley Counties. This school year-long program combined interactive learning about community issues in a setting that builds community relationships throughout the Musselshell River Valley. Participants shared that what they learned from participating in the program had a positive impact on their families, work, and community. One shared that "so much of what I learned on a personal level will help me be a better professional." Participants shared that Leadership 44/53 made a considerable impact on them and the way they engage in leadership roles. Members from the 2019 class put their leadership skills to work to design Leadership 44/53 2020 for the second class. Participants are confident this program will continue to grow relationships and leaders that will allow these communities to continue to thrive. (Change in knowledge)	Community Development 8
139.	Rosebud and Treasure Counties MSUE Family and Consumer Sciences Agent Seeing Big Impacts from New County-Wide Leadership Development Program.	Rosebud County's first ever community-based leadership program, Leadership 29, took form thanks to the vision and guidance of the MSUE Family and Consumer Sciences Agent. Leadership 29 encourages local people to become informed, engaged, and skilled leaders. It brings people together to build relationships, learn about current resources and issues and provides opportunities to increase skills around conflict resolution, communication, generational differences, personality and leadership styles. In its first year, Leadership 29 attracted participants representing businesses, schools, government agencies, non-profit organizations, and more. The positive feedback and rippling impact within communities is surging. Because of the program, individual entities are requesting additional leadership training for staff. Likewise, participants are sharing what they have learned about local resources with employees. One participant stated, "I've lived in Rosebud County for over 30 years and I didn't know this…" Expanded leadership capacity is vital to rural communities. Recent research conducted at the University of Minnesota	Community Development 8

		suggests rural communities lack leaders and need more people to take on leadership roles; the agent shared that "our small-towns are changing, many are facing tough futures and if we want them to be sustainable and vibrant, we must collectively work together and invest in the people who call these wonderful places home. Increased leadership capacity will result in better decision making." (Change in knowledge)	
140.	Jefferson County MSUE Community Development Agents Help the Community of Boulder Work Together to Succeed After the Closing of a Major Employer by the State Legislature.	The journey to transform the Boulder, Mont. community with the loss of a major employer, the Montana Developmental Center (MDC), continues through the community-based Boulder Transition Advisory Committee (BTAC) supported by Extension. These active participants are involved in committees linked to BTAC including an MDC Reutilization, Community Health, Marketing, and the Boulder Development Fund Board. A community $500,000 legislative appropriation is helping to mitigate the economic impacts from the MDC closure and is seeing good progress in several projects with Extension providing assistance and leadership. The Boulder Downtown Master Plan project has successfully started a $100,000 business revolving Loan Fund, a $50,000 downtown Façade Improvement Program, establishment of wayfaring signs, development of a Boulder brand and logo, approval of two gateway signs, a city hall expansion project that will provide outdoor restrooms and stage to increase community park activities, new high-speed fiber internet lines, upgrades to the recreation complex, development of a Boulder River recreation trail, and several other projects in development.	Community Development 8
141.	Mineral County MSUE Community Development Agent Builds Coalitions and Focuses Efforts on Addressing the Lack of Workforce Housing in the County.	Affordable housing has been a problem in Mineral County for years and continues to plague the area. Through a series of strategic planning initiatives, affordable and workforce housing has been identified as one of the biggest barriers to economic growth in Mineral County and throughout the region. As a result, public, private, and non-profit organizations have become determined to address this issue. Mineral and Sanders Counties successfully received grant funds through the Rural Community Development Initiative (RCDI), a USDA program. RCDI grants are awarded to help non-profit housing and community development organizations, low-income rural communities and federally recognized tribes support	Community Development 8

		housing, community facilities and community and economic development projects in rural areas. Funds will be used to benefit the partners in the region through the completion of a joint housing assessment in both Mineral and Sanders counties. The Mineral County Commission prioritized a county-wide assessment and matching funds to build the capacity of supporting organizations to move project development and implementation forward.	
142.	Northeastern Montana MSUE County Agents Partner to Help Teachers Earn Licensure Renewal Credits Near Home, Saving the Teachers and Schools Money and Learning in Their Own Backyards.	Northeastern Montana MSUE Agents hosted "Archaeology and Paleontology," a Teacher Training Workshop as a collective effort among Daniels, Richland, Roosevelt, and Sheridan Counties. The paleontology dig and camp setting was a first for 19 educators from the surrounding area. Participants earned recertification of their teaching license, PIR days, or credit towards salary advancement. The majority of the teachers received OPI Renewal Credit, while some received undergraduate or graduate credit. Teachers toured the Carter County Museum in Ekalaka, which is a sister museum to MSU's the Museum of the Rockies in Bozeman. The museum staff showcased curriculum and lesson plans on paleontology and archaeology. The paleontology portion included a half-day dig in the field on one of the museum's microsites in the Hell Creek Formation. Guest speaker John Ashley presented "Saving our Stars: Documenting the Montana Night Sky." Ashley, a photographer and biologist, has captured elusive Montana beauty that can only be found in the dark – comets, meteor showers, shooting stars, northern lights and the Milky Way. In addition to the professional development and licensure renewal credits, teachers save time and thousands of dollars in travel costs compared to more distant training opportunities. (Change in knowledge)	Community Development 8 Youth and Family Development 7
143.	Flathead County MSU Extension Agriculture and Natural Resources and Community Development Agent Helps Agritourism Grow and Succeed in Montana	Non-resident travel directly contributed $614.2 million to the economy of Flathead County in 2018. When adding indirect economic activity, tourism contributed $824 million to the region. The MSU Extension Agriculture and Natural Resources and Community Development Agent has assisted with legislation that limited liability for agriculture producers in order to have tourists visit their farms, assisted in developing a Montana Agritourism manual for agriculture producers to begin farm-based activities,	Community Development 8

		coordinated local farm dinners for travel writers, helped develop and teach a multi-functional farming class and is a resource for farmers in Montana who are contemplating diversifying their income. The agent belongs to the National Extension Tourism team and was appointed by the Governor to serve on the Tourism Advisory Council for the state of Montana. Her work gives MSU Extension a voice at the table in guiding how visitors perceive Montana and how the bed tax is allocated in research and management strategies. (Change in knowledge)	