FY 2020 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 FY 2020 Plan of Work located in the Institutional Profile. Use this space to provide updates if 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 2020 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 ONLY**
1. The Merit Review Process	None
2. The Scientific Peer Review Process	None

III. Stakeholder Input

The NIFA reviewer will refer to your 2020 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 ONLY
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. Critical Issues Table of Contents

V. Activities and Accomplishments

Please provide information for activities that represent the best work of your institution(s). In your outcome or impact statement, please include the following elements (in any order): 1) the issue and its significance (e.g. who cares and why); 2) a brief description of key activities undertaken to achieve the goals and objectives; 3) changes in knowledge, behavior, or condition resulting from the project or program's activities; 4) and how. Please weave supporting data into the narrative.

No	Project or Program Title	Outcome/Impact Statement	Critical Issue Name or No.
1	**COA research team uses methods from animal and health sciences to detect COVID-19 in wastewater, a faster way to detect community spread than testing individuals**	**Issue:** The Wiedenheft laboratory usually researches how bacteriophages (viruses of bacteria) subvert the bacterial immune system to successfully infect their host, and how bacteria defend themselves against bacteriophages. They seek to understand and engineer cells with new functions for application in medicine and biotechnology. In late 2019, COVID-19 was identified as the cause of the emerging pandemic. **What has been done:** The research team learned that COVID-19 could be detected using genetic tools in fecal material. They mobilized to begin sampling the wastewater entering the Water Reclamation Facility in Bozeman, MT. Samples were collected daily and analyzed in the NIFA- and MAES- funded lab. **Results:** The research team was able to detect COVID-19 two to four days sooner than was possible by testing individual persons in the medical system. This strategy for community-wide testing could alert public health officials and the medical community that the virus is present in the population before human testing can confirm the presence of the virus. Results could be extrapolated to other epidemics and other diseases of humans. 1. One undergraduate student has been trained in the research. 2. Two post-doctoral researchers are contributing to and learning from this project. 3. Four journal articles were published. Nemudryi, et al. (2020), Wiegand, et al. (2020), Cicha, et al. (2020), Wiegand and Wiedenheft (2020)	Animal Sciences (1) Healthy Living, Nutrition & Food Safety (7)

		Likely beneficiaries: *Scientific community, students, stakeholders (local, state, tribal, national, international), citizens (local, state, tribal, national, international)* *Discovery, Engagement* *Change in knowledge*	
2	**MAES researchers expand understanding of microbial interactions with cattle.**	**Issue:** Cattle production is a key economic driver in Montana. Limitations to calf production and growth reduces the efficiency in beef production in the United States. The Yeoman and Thompson research teams are taking unique approaches to increasing understanding of factors that limit beef production in animals. Both teams strive to understand the basic science foundations to these limitations and to find practical solutions that improve cattle performance in real world situations. **What has been done:** The Yeoman research team is studying the microbes that populate the gastrointestinal tract (GIT) of mother cows and their calves. They have determined that approximately 44% of the microbial population of the calf's GIT comes from the mother's colostrum and surface of the udder and teats as the calf feeds. The Thompson research team is studying complex genetic traits to make production improvements in beef cattle. They seek to discover economically important traits influencing production efficiency in mother cows such as carcass and meat quality, and the effects of inbreeding depression on these traits. **Results:** The Yeoman team identified 56 microbial taxa that may influence calf immune development. They are also exploring microbial populations in ruminant	Animal Sciences (1)

		wildlife to determine if microbes can confer resistance to some poisonous plants. • Three undergraduate students have been trained in this research. • Two graduate students have been trained and contributed to this research. • One post-doctoral researcher has learned from and contributed to these research efforts. • Three journal articles have been published. Sanglard, et al. (2020), Borgogna, et al. (2020), Ishaq, et al. (2020) • Four conference papers have been presented. • Three ileum Enteroid models have been developed from Angus cross-breed cattle. The Thompson team has developed biologically-based predictors that have potential to improve the accuracy and reliability of genetic selection and improvement in beef cattle. They have also quantified the impact on inbreeding depression in two separate lines of Hereford cows. • One undergraduate student was trained in this research. • Two graduate students were trained and contributed to this research. • One PhD. dissertation was completed and defended. • One Master's thesis was completed and defended. • Three conference papers were presented. ***Likely beneficiaries:*** *Scientific community, students, stakeholders (meat industry)* *Discovery* *Change in knowledge*	
3	**Winter grazing research seeks to reduce rancher dependence on hay**	**Issue:** Feeding cattle in the winter using hay harvested in the summer is more expensive in Montana than other areas of the country. Ranchers would like to more effectively use grazing of dormant forage during the fall and winter months to reduce the cost and labor of supplemental feeding. In both dormant	Animal Sciences (1)

	for winter feeding and gain an understanding of how cows react to feed supplement strategies in extensive winter grazing settings.	grazing and supplemental forage feeding systems, protein and mineral supplements are required and accessing them can be measured using new technologies. **What has been done:** The DelCurto research team studied how cows accessed self-feeding supplements including both food meal and salts in winter range conditions over two years. The cows ranged in age from 1 to 12 years of age and were grazing from late fall to early winter. Access and consumption of feed supplements was tracked using electronic identification ear tags and feeding stations equipped with consumption and visit monitoring capabilities. Weather data was collected and matched to cow feeding events. **Results:** This research found cow age and weather can impact daily supplement intake, variation in supplement intake, and daily visits to the supplement feeder. Most importantly, this research examined the "common wisdom" that older cows visit supplement feeders more frequently and consume more supplement. This research found that the opposite was true; younger cows access the supplement feeder more often and consume more supplement. It is believed that lower body weight and fat requires younger cows produce more metabolic heat for maintenance of normal body heat. The team found the effects of cow age on daily supplement intake were mediated by weather. When windchills were below average, visits to the supplement feeder and daily intake decreased and variability increased with cow age in both years of the study. The same was true for average windchills in year one, but not year two. This study confirmed other research that windchill can have a significant impact on beef cattle behavior. • Four undergraduate students have been trained in this research. • Seven graduate students have been trained and contributed to this research. • Four post-doctoral researchers have learned from and contributed to these research efforts.	

		• Four journal articles have been published. Wyffels, et al. (2020a), Wyffels, et al. (2020b), Wyffels & DelCurto (2020), Dafoe, et al. (2020) • One book chapter has been published. Putnam, et al. (2020) • Seven conference papers have been presented. ***Likely beneficiaries:*** *Scientific community, students, Extension professionals, stakeholders (beef producers and industry)* *Discovery* *Change in knowledge*	
4	**Blaine County MSUE comes through no matter the obstacles.**	*This report is representative of the successes many local offices had during 2020.* **Issue:** Blaine County agriculture producers faced many challenges in 2020. In a year that included the COVID-19 pandemic, uncertain commodity prices, catastrophic failure of Drop 5 in the St. Mary's irrigation canal system on the Milk River, grasshopper infestation, wind, and drought; producers were still able to reach out to Blaine County MSUE for assistance. **What has been done:** At the beginning of the COVID-19 pandemic, MSUE was very quick to gather available resources into one website. MSUE shared the website with constituents on their Facebook page as well as through local news media outlets. Throughout the year, MSUE staff assisted over 150 producers in Blaine County through forage testing, insect and weed identification, plant disease diagnostics, plant variety information, ration balancing, feed analysis, range monitoring, private applicator testing, and nitrate testing. Blaine County MSUE was able to work with producers to provide these services through contactless means. **Results** • More than 50 forage samples were submitted for feed nutrient analysis. These samples represented over 7,000 acres (over 20,000	Animal Sciences (1) Plant Sciences (2)

		tons) of forage produced in the county. Producers appreciate the low cost of analysis and speed of results. • With producers unable to irrigate normally this year, coupled with drought conditions, nutrition analysis results were a vital tool for producers when pricing and purchasing forage. • In addition, more than 40 samples had nitrate levels tested (high nitrate levels in feed can be toxic to livestock). Less than 20% of the samples came back with elevated nitrate levels; of those, all were still in the 'safe to feed under all conditions' classification. This year, the nitrate test samples represented over 2,000 acres (4,000 tons) of forage that could still be used for livestock consumption. Through testing, producers know forage can safely be used, thus saving an average $25 per ton versus having to purchase additional feed. These services provided by MSUE in Blaine County allowed producers to make informed decisions about their operations, thus improving their bottom line. Overall, requests to Extension by constituents for services and additional information has increased by 20% over the past year. ***Likely beneficiaries:*** *Citizens (local agriculture producers)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	
5	**Yellowstone County producers save money when working with MSUE.**	*This report is representative of the successes many local offices had during 2020.* **Issue:** COVID-19 and the associated shelter-in-place and other restrictions impacted the nation beginning in March. All of the COA, MAES, MSUE and our clientele responded to these changes with innovation, adaptation, and success. For local MSUE offices, our high-touch interactions with clientele virtually stopped overnight.	Animal Sciences (1) Plant Sciences (2)

		What has been done: Extension professionals and clientele were able to rapidly adopt and accept distance and virtual approaches to continuing vital local relationships and interactions. Virtual meeting tools, social media, websites, and appropriate and safe in-person interactions became the norm with great effect. These adaptations are present across all MSUE disciplines. Despite COVID-19 challenges, Yellowstone County MSUE agent Callie Coolie continued site visits following safety protocols. Life did not stop for agricultural producers who continued to face challenges on their operations, so fortunately, Coolie was able to safely provide services and information to those seeking assistance. From February to October, 32 site visits and 10 field inspections were completed. **Results:** Implementation of social media and virtual strategies met clientele needs in a timely manner. These social media also reached beyond the locally bound clientele to regional, multi-state, and international audiences in some cases. Coolie's visits represented approximately 875 cropland acres, 350 rangeland acres, and nearly 800 cattle, all positively impacted as a result of consulting with MSUE. Producers sought assistance for a wide array of issues: • One consultation with a producer led to a winter tetany diagnosis with his steer calves. By working with Coolie to find a solution, the producer to halted death loss. Failure to identify and solve the problem could have cost the rancher nearly $150,000. • Acres inspected and certified as noxious weed seed free were up nearly 400 percent. As a result, approximately 845,000 pounds of straw and 211,000 pounds of hay used for things including highway reclamation projects and use on public lands will not contribute to the spread of noxious weeds. ***Likely beneficiaries:*** *Stakeholders (local, state, national governmental land management agencies), Citizens (local agriculture producers)*	

		Engagement *Change in knowledge, Change in Intention, Change in Behavior*	
6	**Not everything revolved around COVID-19. Natural disasters and pestilence reared their heads as well.**	**Issue:** While COVID-19 impacted virtually everything in 2020; life and agriculture in Garfield County demonstrated how agriculture and the community faced many other challenges. **What has been done:** Garfield County MSUE Agent Miller provided leadership as his communities faced several challenges beyond COVID-19. This frontier county didn't have a high number of COVID-19 infections; however, they did face many challenges in 2020. **Results:** 2020 presented challenges to almost everyone in Garfield County. Destructive grasshoppers wreaked havoc on pasture, crops and gardens from mid-summer through the fall. MSUE worked with many individuals to find options and solutions for grasshopper management. Price of return vs. price of management models were used to help make rational decision for crops and pastures. In gardens, emotional response won out; therefore, educational materials and validated methods of control were advocated to reduce the destruction hoppers created in most yards and gardens in the county. The Huff wildfire had a dramatic impact on the community in September. Thousands of acres of fall grazing coupled with the entire hay crop were burned in a single afternoon. Livestock were scattered and fences wiped out. MSU Extension worked with local emergency units to manage post-fire issues and provided assistance to some impacted producers in the form of feed and livestock management options. 2021 will bring the need for grazing, revegetation, and weed management education and assistance to the forefront for many of the affected operations. ***Likely beneficiaries:*** *Citizens (local agriculture producers)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	Animal Sciences (1) Plant Sciences (2) Farm, Ranch and Business Management (3) Integrated Pest Management (4) Energy & Natural Resources (5)

7	**COA and MAES researchers increase understanding of disease treatment in domestic animals which informs human health treatments.**	**Issue:** 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, although vaccines against many of the causative agents have been available for years. Only marginal improvement in non-predator calf survival has been observed over the past few decades despite the availability of vaccines. Strikingly, digestive and respiratory diseases still account for nearly 50% of the non-predator deaths in calves. Causes of these diseases addressed included Escherichia coli (scours or diarrhea), Mycoplasma ovipneumoniae (pneumonia), Heliobacter suis (gastritis and ulcers), Streptococcus equi (upper respiratory diseases), and Brucella abortus, the cause of a fever disease called brucellosis. Mycoplasma ovipneumoniae, which causes pneumonia, is very common in domestic sheep and can be associated with economic losses both because infection makes lambs susceptible to more severe disease caused by other pathogens, and because risk of transmission to wild sheep has caused restrictions on grazing of domestic sheep on public lands. These restrictions are in place because infected domestic sheep can transmit bacteria to bighorn sheep that die from these infections. **What has been done:** 1. The Jutila research team identified an antibiotic treatment, amphotericin B, which provided broad spectrum control of naturally occurring scours caused by Escherichia coli in newborn calves. 2. The Rynda-Apple research team tested whether virus-like particles (VLPs) can be used in domestic sheep to treat atypical pneumonias commonly caused by Mycoplasma ovipneumoniae, a cell-wall less bacteria. This research is making progress to develop a vaccine to protect sheep from infection. 3. The Bimczok research team continues to study Helicobacter suis, a gastrointestinal pathogen of swine, using the model of the human	Animal Sciences (1) Energy & Natural Resources (5) Healthy Living, Nutrition & Food Safety (7)

		pathogen H. pylori. This research is identifying how the pathogen affects cells in the stomach and its carcinogenic effects. 4. The Lei team's research efforts have advanced to the point where the mechanisms of transmission of Streptococcus equi are understood between nasal infection, the throat, and the differences in the body's defense mechanisms' efficacy on mucus membranes and the skin. **Results:** The research conducted in these COA labs is providing valuable results that will improve the success of Montana livestock producers. New and novel treatment strategies for pathogens impacting calf production, reducing the risk of infection of the big horn sheep population by protecting domestic sheep, and understanding the cellular mechanisms that result in the formation of cancer cells in humans and animals are promising developments for animal agriculture and human health. 1. The Jutila research team reported the sequence analysis of the new phage in a manuscript in 2020. Efficacy experiments were done in the past year on different phage preparations. They found that less phage is better as a treatment and when high doses of phage are reduced, clearance of Brucella abortus was seen. a. Three undergraduates were trained in this research b. One journal article was published. Chica, et al. (2020) c. Two conference papers were presented 2. The Rynda-Apple research team investigated the role of sheep alveolar macrophages (cells of the immune system) in response to inoculation with virus like proteins and whether they resulted in clearance of pneumonia-causing pathogens. The team found that the anti-bacterial effect of alveolar macrophages varied in relation to the timing of Mycoplasma ovipneumoniae infection, such as Staphylococcus aureus when compared to alveolar macrophages isolated from non-infected sheep. *These results also demonstrate that certain virus like proteins can be rapidly modified in a modular fashion, resulting in an effective vaccine construct that can generate protective immunity without the*	

		need for additional adjuvants. To begin to address the gap in knowledge about cattle and other ruminant response to Influenza D viruses (IDV), the Rynda-Apple team's study evaluated host cellular responses against primary IDV infection and secondary bacterial infection with Staphylococcus aureus (S. aureus). IDV infection appeared to protect mice from the usual clinical features of secondary bacterial infection, as demonstrated by improved weight loss, survival, and recovery when compared to S. aureus infection alone. A notable increase in IFN-β expression following IDV infection was found. *These results demonstrate for the first time that IDV infection does not increase the susceptibility of the host to secondary bacterial infection with S. aureus, with evidence that anti-viral immune responses during IDV infection might protect the host against these potentially deadly outcomes.* a. Two undergraduate students were trained in this research b. Two graduate students were trained through this research c. Two journal articles were published. Sharma, et al. (2020) and Skelton, et al. (2019). 3. This research by the Bimczok research team is expanding the understanding of how Heliobacter pylori affects the genetic makeup of cells in the human stomach and how this mechanism creates carcinogenic effects. a. Four journal articles were published. Roe, et al. 2020, Sayed et al. 2020, Sierra, et al. 2020, and Caston, et al. 2020 4. The Lei team's research demonstrated a mechanism that effectively clears Group A Streptococcus (GAS) from the lung by neutrophils; this mechanism is compromised on the skin. The results support a model to explain that GAS can generate an anoxic niche in the skin for evading killing by neutrophils and conferring resistance to clearance; in an oxic environment, such as the lung, GAS cannot establish infection. a. Two undergraduate students were trained in this research	

		b. One journal article was published ***Likely beneficiaries:*** *Scientific community, regulatory authorities, students, Extension professionals, stakeholders (local, state and tribal landowners, livestock producers and industries) citizens (local, state, tribal, tourists).* *Discovery* *Change in knowledge*	
8	**Increasing food security through home gardening in Big Horn County.**	*This report is representative of the successes many local offices had during 2020.* **Issue:** While many closures happened due to the COVID-19 pandemic, MSUE in Big Horn County never stopped. Class formats were adjusted or changed to meet local and state health requirements while still serving the people of Big Horn County. One excellent example of flexible program delivery was the Gardening 100 series. **What has been done:** This in-person series about basic gardening information became a weekly short video posting on the Big Horn County MSUE Facebook page. The first video included topics on how to choose the correct seed for a growing area, for planning around frost free days, when to start seed indoors, and how to read seed packets. Other videos included how to start seeds at home with information about soil media, watering, and other tips for success; nutrient information for seedlings; when and how to transplant seeds into larger pots; and how to prepare a garden site before planting. The garden site preparation included information about proper pesticide use, as well as using a dark tarp to help decrease the weed seed bank prior to gardening season. **Results:** There was an excellent response to the video format, with over 400 people reached on the Big Horn County MSUE Facebook page. Timing was important as ever with these videos, as many people across Big Horn County,	Plant Sciences (2)

		and the nation, were establishing gardens and growing their own food for the first time while coping with COVID-19. ***Likely beneficiaries:*** *Citizens (local, state, tribal, national)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	
9	**Increasing soil acidification of crop production fields in Montana is being solved by COA and MSUE faculty.**	**Issue:** During the past five to ten years, Montana farmers have observed patches of poor-performing crops in fields across Montana. The cause was initially elusive. The symptoms ranged from chlorotic and stunted plants to necrosis and plant death in patches of fields. MSUE and COA faculty member Jones collaborated with colleagues, farmers, and MSUE county agents to identify that soil pH was low in these areas of the field, a new phenomenon for Montana's traditionally neutral to basic soils. Low pH soils had more aluminum available to plants, which was toxic. The soil pH varied across fields and was ideal for precision agriculture-based solutions. **What has been done:** MSUE and COA have been quick to respond to this crisis in crop production. Jones, MSUE soil fertility specialist, collaborated with agents in affected counties. It was determined that 24 counties were impacted with estimated yield losses of 10 to 40 percent due to acid soils. Jones increased awareness and understanding of the needs and scope of problem via Extension talks and surveys of MSUE agents, Certified Crop Advisors, and producers. An educational video was produced in 2020 to help producers and crop advisors address low soil pH via research and evidence-based engagement strategies. Additionally, MAES researchers have embarked on research projects that explore precision agriculture in broader contexts and also have specific applications to low soil pH issues facing many Montana producers today.	Plant Sciences (2)

		Results: Jones developed the MAP strategy (Mitigate, Adapt, Prevent) for managing low soil pH. The MAP strategy recommends soil amendment to raise pH, selection of aluminum tolerant varieties, phosphorus fertilizer application to tie up aluminum, timing nitrogen application to match plant demands, applying variable rates of nitrogen, or planting crops that have lower nitrogen demands. The video Acidification of Cropland Soil: Impact, Causes, and Solutions has received over 1,300 views since it was published. ***Likely beneficiaries:*** *Extension professionals, stakeholders (local, state, tribal, national, international agriculture producers and professionals), citizens (local, state, tribal, national, international)* *Discovery, Engagement* *Change in knowledge, Change in Intention, Change in Behavior, Change in Condition*	
10	**Research-based recommendations on cover crop establishment and management help producers find greater success with cover crops with the potential to increase soil organic matter, decrease soil erosion, and dependence on herbicides for chemical fallow systems.**	**Issue:** "Fallow-based cropping systems in semi-arid regions have been profitable and often less risky than recrop; however, their use is damaging to soil health and may limit long-run profitability. Cover crops can reduce summer fallow while possibly improving soil health. This article addresses cover crop management impacts on soil organic matter, soil water and N, and subsequent cash crop yields and grain protein concentration" Jones, et al. (2020) **What has been done:** MSUE's Jones and MAES's Olson-Rutz, Miller, and Zabinski published "Cover Crop Management in Semi-Arid Regions: Effect on Soil and Cash Crop" in Crops & Soils Magazine. These MSUE and MAES faculty synthesized over 15 MSU research efforts over the past 12 years and reviewed cover crop literature from the across several land grant universities and other institutions across the world to help Extension professionals, crop consultants and producers make evidence-based decisions about cover crop production systems and strategies.	Plant Sciences (2)

		Results: This effort is crucial to successful implementation of cover crop strategies because there are many voices promoting several cover crop strategies that may or may not be applicable in Montana's climates. This article reaches a public audience and provides answers based on the research of many scholars over several years and climatic situations. Overall, they found **"**cover crop diversity over time or with mixed-species plantings is desirable to provide multiple cropping system benefits. If growing plant residue to increase SOM [soil organic matter] is the goal, using a multi-species mix of cover crop may supply a more reliable and consistent amount of biomass but generally does not produce more biomass than a well-adapted single species such as pea. At low-to moderate N fertilizer levels, cover crops that contain legumes generally produce high biomass, leading to increases in SOM as well as providing PAN [plant available nitrogen]. Early- to mid-season termination of summer fallow replacement cover crops is suggested to minimize soil water depletion and subsequent small-grain yield losses. To gain SOM in semi-arid regions, the cover crop-cash crop rotation should produce at least 1.8 tons/ac of above ground dry biomass per year. The biomass gained by allowing a cover crop to grow to full maturity may not offset the wheat stubble loss due to lower small-grain yields the following year because of low soil water. Generally, N from legume cover crops increases wheat protein while it may take several legume cover crop rotations before the added N benefits wheat grain yield. Soil N levels should be tested and fertilizer N rates adjusted following cover crops" Jones, et al. (2020). ***Likely beneficiaries:*** *Extension professionals, stakeholders (local, state, tribal, national, international agriculture producers and professionals), citizens (local, state, tribal, national, international consumers)* *Engagement* *Change in knowledge*	
11	**Novel three-way interaction between**	**Issue:** Traditionally it is thought that viruses act solely as pathogens in which the host tries to eliminate viral infection. Hence, viruses are thought to control	Plant Sciences (2)

	a virus, a parasite, and a host discovered.	community composition by negatively impacting the fitness of infected hosts including plants. The Young research team proposed an alternative hypothesis that chronic viral infections contribute positively to host fitness, increasing the success of the virus-host pair. This hypothesis holds that in highly competitive microbial communities, chronic virus infection protects hosts from infection by more pathogenic viruses. **What has been done:** Progress on the study of the role of viruses in influencing microbial hosts and virus community structure and function has been made. **Results:** The Young research team has isolated and characterized a new type of archaeal virus that itself infects a parasite that infects another cell type. *This is the first time* that a virus has been isolated that is involved in such a three-way molecular cellular interaction. • One post-doctoral researcher has learned from and contributed to these research efforts. • Four journal articles have been published. Hartman, et al. (2020), Lawrence, et al. (2020), Munson-McGee, et al. (2020), Wirth & Young (2020). • One journal article has been submitted. **Likely beneficiaries:** Scientific community, students *Discovery* *Change in knowledge*	
12	**COA and MAES public breeding programs fill niche seed markets important to**	**Issue:** Public breeding programs are an important part of agriculture in the Northern Great Plains. Unique climate challenges and relatively limited market conditions for seed sales result in commercial seed licensed from COA and MAES breeding programs that serve a large portion of the seed market. **What has been done and results:**	Plant Sciences (2)

	Montana agriculture.	• The Bruckner winter wheat breeding team developed an herbicide resistant 'Clearfield' winter wheat cultivar, 'StandClear CLP,' which was licensed and released. Variety performance information was disseminated to wheat producers. 1005974 (REEport accession number) • The Giroux research team characterized the genetic variation in genes impacting wheat, barley, or pulse crop growth and development and those that impact product quality traits. They have documented specific alleles and germplasm sources for traits such as reduced noodle darkening, reduced wheat and barley pre-harvest sprouting, pulse crop seed color and increased seed amylose content. Vetch, et al. (2020). 1014546 • The Fischer research team identified a genetic trait in malt barley that confers earlier flowering (anthesis) associated with the 'Lewis' HvGR-RBP1 allele and combined that trait with later maturation (staying green longer) due to presence of the 'Karl' HvNAM1 allele to extend grain fill duration by ~3.1 days overall in one experiment. This positively influences the percentage of plump kernels and test weight, and substantially decreases grain protein; these are all desirable outcomes in malt barley varieties. 1022622 • The Giroux 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. They tested wheat under field conditions and found that leaf starch levels vary substantially in comparison to recent and historically important wheat varieties. They then selected two recombinant inbred line populations to test in which the parents vary for leaf starch and grew them in the field. They measured productivity and are now measuring leaf starch to determine whether native leaf starch levels impact yield. An additional trait of interest they are studying is genes impacting wheat and barley pre-harvest sprouting.	

		They identified allelic variants in both wheat and barley that could be used to reduce pre-harvest sprouting in locally adapted wheat and barley varieties. The barley study was significant in that *they were the first to look at major genes impacting barley dormancy among a wide range of malt and feed varieties*. Vetch, et al. (2020), Jobson, et al. (2020). 1009528 • The Kephart research team established wheat and barley nurseries to evaluation promising new genetic traits for southern Montana. Analysis of the results indicated that "the stay-green trait was significantly correlated to overall yield ($P < .001$, $r = .37$) in rain-fed environments, but was not significantly correlated to yield ($P = .26$, $r = .09$) in irrigated environments. Three quantitative trait loci (QTL) located on chromosomes 2D, 4A, and 4D were associated with the stay-green trait. The 4A stay-green QTL, previously designated *QGfd.mst-4A*, was collocated with QTL for seed number per head, thousand kernel weight, and heading date. The 4D stay-green QTL overlaps the *Rht-D1* plant height gene, and the allele prolonging the stay-green period co-segregates with the wild-type (tall) *Rht-D1a* allele. Results from this study provide a better understanding of the relationship between stay-green and agronomic traits in rainfed vs. irrigated environments. Additionally, understanding the genetic architecture controlling stay-green and agronomic traits will aid in selecting future drought-tolerant spring wheat varieties". Cook, et al (2020) 1019028 Collectively, these research efforts accomplished the following: • Ten undergraduate students have been trained. • Eight graduate students have been trained and contributed. • Three journal articles have been published. • One journal article has been submitted. • One patent application. ***Likely beneficiaries:*** *Scientific community, students, Extension professionals, MAES research centers, stakeholders (local, state, tribal, national, international*	

		agriculture producers and professionals), citizens (local, state, tribal, national, international consumers) *Discovery, Engagement* *Change in knowledge, Change in Intention*	
13	**Improving sugar beet irrigation efficiency can maintain sugar yield and reduce costs of production, transportation, and processing.**	**Issue:** Sugarbeets are valued by both yield and sugar content. "Irrigation is important to sugarbeet… production and efficient irrigation management is critical for yield, sugar concentration, water use, and environment quality" Nilahyane, et al. (2020). **What has been done: "**Two irrigation studies were conducted to investigate sugarbeet response to deficit irrigation under conventional tillage… and no-till… systems in 2016 and 2018. The irrigation treatments included full irrigation (100% crop evapotranspiration) and deficit irrigation (66% crop evapotranspiration), and two irrigation cutoff dates (15 and 30 d before harvest). Plant population, soil moisture, sugarbeet root yield, sucrose concentration, and impurity value were measured" Nilahyane, et al. (2020). **Results: "**The results of this study indicate the potential of implementing a deficit irrigation strategy in sugarbeet as a beneficial tool to reduce the amount and increase the efficiency of the irrigation water applied under CT and NT systems, but in the future, in-situ soil moisture sensor data must be incorporated into the irrigation scheduling to avoid severe water stress under deficit irrigation. Stopping irrigation 30 d before harvest slightly reduced the sugarbeet root yield but did not affect extractable sugar yield, suggesting that omitting one irrigation late in the growing season may not reduce root yield and quality, and could bring some benefits of lower transportation weight and volume. Deficit irrigation in conjunction with a NT system could be a beneficial strategy for sustainable sugarbeet production" Nilahyane, et al. (2020). • One undergraduate student was trained in this research. • One post-doctoral researcher led and learned through this research. • One journal article was published. Nilahyane, et al. (2020).	Plant Sciences (2)

		• Three conference papers were presented. ***Likely beneficiaries:*** *Scientific community, Extension professionals, stakeholders (local, state, tribal, national, international sugarbeet producers and professionals), citizens (local, state, tribal, national, international consumers)* *Discovery, Engagement* *Change in knowledge*	
14	**MAES Explored Cropping Systems to Replace Chemical Fallow and Improve Soil Health**	**Issue:** Central Montana agriculture has relied primarily on rotations containing 'fallow,' not planting a crop to allow the soil to accumulate water. This is becoming increasingly unsustainable from an economic perspective and has detrimental ecological consequences including topsoil erosion and groundwater contamination. There has been an increasing awareness of the importance of transitioning to sustainable agroecosystems that can meet production goals with fewer negative ecological effects. There has also been an increased recognition of the importance of microorganisms in soil health and productivity. **What has been done:** The Eberly research team has studied microbial inoculants and soil amendments, the change in microbial populations, and identified microbes capable of solubilizing phosphorus. **Results:** Azospirillum, Azotobacter, and Bacillus inoculations showed that in irrigated alfalfa, organic matter increased from 5.9% in the control to 7.3% in the inoculated plots. Active fungi in the soil increased by 50% in plots treated with a complex blend of beneficial microorganisms. Efforts are focused on isolating novel phosphate-solubilizing microorganisms and evaluating their performance. Six isolates capable of effectively solubilizing phosphate have been identified. Ongoing work is focused on identifying these isolates and determining rates of solubilization.	Plant Sciences (2)

		Likely beneficiaries: Scientific community *Discovery, Engagement* *Change in knowledge*	
15	**Chouteau County MSUE agent meets the needs of farmers in the Golden Triangle.**	*This report is representative of the successes many local offices had during 2020.* **Issue:** COVID-19 and the associated shelter-in-place and other restrictions impacted the nation beginning in March. All of the COA, MAES, MSUE and our clientele responded to these changes with innovation, adaptation, and success. For local MSUE offices, our high-touch interactions with clientele virtually stopped overnight. **What has been done:** Agricultural education and outreach for farmers was achieved through the Golden Triangle Cropping Seminar. Producers learned about oilseed production, insect pests, agricultural product marketing, Alzheimer's disease, web-based tools for agricultural producers, and fungicide efficacy in Montana crops. **Results:** • Five producers planned to use the Southern Agricultural Research Center web-based tools to assist with management decisions. If five producers managing 2,000 acres were able to save 50 pounds per acre in a urea fertilizer application, their cost savings could total $50,000. • Integrated Pest Management (IPM) of Wheat Stem Sawfly and Ascochyta Blight was presented at Initial Pesticide Applicator Trainings in Hingham, Chester, Fort Benton, and Billings. There were 118 producers who were updated on IPM of the wheat stem sawfly and Ascochyhta blight in chickpeas. Producers developed knowledge and understanding of integrated pest management, promoting profitability, and sustainability of agricultural operations.	Plant Sciences (2) Integrated Pest Management (4)

		○ After the update, producers commented on the need to keep better records, use more rotational crops, scout their peas more, and learn about the Bobcat winter wheat variety and to learn how to better identify different insect infestations. • Calibration of Sprayers was presented at the Initial Pesticide Applicator Training in Hingham. Producers were updated on calibration techniques and shortcut formulas to increase spraying efficacy. Producers developed knowledge and understanding of research-based calibration techniques, promoting profitability, and sustainability of agricultural operations. • Integrated Pest Management (IPM) presentation of Pale Western Cutworm, Army Cutworm, and Wheat Stem Sawfly in Carter. Producers developed knowledge and understanding of IPM, promoting profitability, and sustainability of agricultural operations. ○ One producer commented that they will scout fields more often. Pheromone traps were distributed and monitored for Orange Wheat Blossom Midge Monitoring (OWBM) and Wheat Head Army Worm (WHAW). Counts and sweeps were below treatment threshold levels. • Testing for soil moisture took place in Chouteau County on March 24-26. All winter wheat locations exceeded 3.5 feet of stored soil moisture. Stubble plots located in the southern regions near Geraldine, Great Falls and Highwood and other sites near the Knees and the Kenilworth highway had excellent recropping potential. ***Likely beneficiaries:*** *Extension professionals, stakeholders (local, state), citizens (local, state)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	
16	**Sustainable Families, Firms, and**	**Issue:** One major weakness of previous research on survival and demise of family-owned businesses after natural disasters is that only survivors have	Farm, Ranch and Business

	Communities in Times of Significant Change, Including During COVID-19.	been studied. It is also important to include owners of businesses that did not survive in order to determine the factors that led to the demise of their businesses. In what ways were they less able to recover? Did they have barriers to recovery that were different than those of businesses that survived? Was the demise of their businesses a choice? What role did the family and community of the owner play in business survival and demise? Another major weakness of past research is that the owning family was left out of the survival equation, yet may play an important role that is not being considered in disaster recovery efforts and policy. Understanding survival and demise after a significant disrupting event such as a disaster is unique in that it stresses families, businesses, and communities simultaneously. Simultaneous stress on systems the family firm habitually depends upon may be an important contributor to business demise. If that is the case, perhaps policy supporting family disaster recovery may be more important than policy supporting business recovery, or at least an important component of it. **What has been done:** • Published a literature review to address the contributions of family business literature in the Journal of Family and Economic Issues. • Understanding COVID-19 and stimulus fund utilization and impact. Using data from the Small Business Administration (SBA), County Business Patterns and SBA 7(a) loan guarantees, this study examined the allocation of Paycheck Protection Program stimulus funds across industries and geographic locations (states). This working paper addresses the responses to negative impacts, such as the pandemic. • Change in small business loans outstanding during the COVID -19 pandemic. Financial stimulus programs were available to borrowers through several financial institutions, including depository lenders, credit unions, and others, during the pandemic. The value of total business loans outstanding by depository lenders increased by 14.8% during the pandemic from December 31, 2019 to June 30, 2020. This	Management (3)

		research examined the additional funding provided by depository lenders; exploring the public policy around the Paycheck Protection Program. **Results:** • This research informed Extension programming throughout 2020. • COVID-19 and stimulus research were utilized in internal Extension professional development and external presentations in late spring and early summer. • The timely research and results on the utilization of COVID-19 funds for businesses was shared via the Purdue Institute for Family Business (p. 3) and AGECONMT at Montana State University. In addition, this work has been utilized by the Office of Advocacy at the US Small Business Administration. • Outreach and engagement presentations have been made to nearly 1,500 participants on these and broader agriculture economic and farm policy topics. ***Likely beneficiaries:*** *Scientific community, Extension professionals, stakeholders (local, state, tribal, national, international), citizens (local, state, tribal, national, international)* *Discovery, Engagement* *Change in knowledge*	
17	**Documenting the impacts of pest management research and the economic impacts.**	**Issue:** Agricultural pest and disease problems cost producers and consumers billions of dollars annually in the United States alone. The role of technological innovation in addressing these issues is important, yet often overlooked for several reasons. The payoffs to this type of investment are often slow in arriving, as crop-based agricultural research often takes a substantial amount time to complete and up-front costs are often in the millions of dollars. However, in general, the rates of return on these investments are high and the benefits that flow from the research far outweigh the costs. This research	Farm, Ranch and Business Management (3) Integrated Pest

		project evaluates costs and benefits from research into specific agricultural pest and disease technologies, and also creates tools that can be used to evaluate these technologies at multiple levels--helping individual growers in their decisions about whether to adopt these technologies, and also facilitates estimates of the net benefits (or costs) of the technology itself. **What has been done:** 1. A partnership with the Montana Wheat and Barley Growers continued. The survey of Montana producers was expanded to include questions that identified desirable and utilized traits. This new information provided MSU plant breeders with a needs assessment directly from producers to inform their breeding efforts. 2. Published "Valuing Disease Prevention in a Vegetatively Propagated Annual Crop: Benefits From the Montana Seed Potato Certification Program" 3. Several presentations incorporating the wheat and barley survey findings as a part of the overall agricultural outlook educational events. **Results:** 1. The Montana Wheat and Barley Grower partnership continues to develop longitudinal understanding of the industry in Montana. The survey gathers grower sentiment looking forward and historically; it identifies industry trends and issues impacting producers; and is a data source when developing market outlooks. 2. The evaluation of the Montana Seed Potato Certification Program examined the economic costs of potato virus Y and benefits to commercial potato growers from using screened seed. Using data and models from Idaho, a major purchaser of Montana seed, it is estimated the annual benefit from Montana's seed potato screening program to Idaho producers is $205 per acre or up to $22 million for the state.	Management (4)

		3. Outreach and engagement presentations have been made to nearly 1,700 participants on these and broader agriculture economic and farm policy topics. One graduate student was trained through this project. ***Likely beneficiaries:*** *Scientific community, students, Extension professionals, stakeholders (local, state, tribal, national, international agriculture producers and professionals), citizens (local, state, tribal, national, international consumers)* *Discovery, Engagement* *Change in knowledge, Change in Intention, Change in Behavior, Change in Condition*	
18	**Farm labor research develops understanding of the impacts and adaptations to labor shortages, policy changes (including during COVID-19), and the impacts of international policy in Mexico's impact on future farm labor supply.**	**Issue:** Rural communities in Montana, the United States, Mexico, and other regions of the world are vitally connected to one another through inter-regional trade and labor migration. Consequently, changes in the rural workforce and agricultural inputs must be studied at the regional, national, and international levels. Mexico is the primary source of agricultural labor in the United States; yet rural Mexico is currently transitioning out of agricultural work, just as the United States did in the mid-twentieth century. As the farm labor supply shared between Mexico and the United States shrinks, U.S. farm wages are rising, Montana's are rising even faster than the national average. Diminishing farm labor supply is expected to impact agricultural production practices, resource demands, and rural communities. This project analyzes trends in the U.S. farm labor supply, measures changes in demand for alternative sources of labor, including foreign agricultural guest workers and family on-farm labor, and simulates the effects of decreased farm labor supply on capital investment, water use, and agricultural technology adoption in the Northern Great Plains. The findings are relevant to agricultural producers, industry leaders, rural farmers, and policy makers in Montana, the Northern Great Plains, and throughout the country. Understanding changes in labor	Farm, Ranch and Business Management (3) Integrated Pest Management (4)

		migration, agricultural labor supply, and supply of other inputs to production is critical for rural economic growth, policy, and planning. **What has been done:** • Two research papers have been published with a third under revision. • Results have been presented in a symposium for the Agriculture & Applied Economics Association. • A workshop for the USDA ERS. • Interviews have occurred on NPRs Planet Money and Michigan State University's "Closing Bell" podcasts. • Presented a professional development webinar for MSUE addressing the impacts of COVID-19 for Extension professionals and producers. **Results:** • Research on the impacts of shifting and rising labor for dairies identified increased reliance on technology to replace labor. The findings show that labor efficiency increases, technology use increases, the share of dairy operators working off-farm increases, but overall dairy production decreases as a result of increased immigration enforcement. • "Rural School Access and the Agricultural Transformation" measured the effects of secondary school construction in rural Southern Mexico on the probability that children grow up to take jobs in the non-farm sector. This has important implications for the U.S. farm sector which depends on an immigrant workforce from rural Mexico. Our findings indicate that rural school construction accelerates the agricultural transformation. As rural Mexico becomes more educated, U.S. farmers will have to seek out alternative labor sources or production methods. • Research completed in cooperation with California Polytechnic State University modeled the impact of California minimum wage policy changes on the demand for labor and head lettuce. Agricultural labor costs have been increasing over the past 2 decades. "This is especially	

<table>
<tr><td></td><td></td><td>the case in California, which is the nation's largest fruit and vegetable-producing state. Recent legislation (SB 3, AB 1513, and AB 1066) will increase the minimum hourly wage for farm workers and requirements regarding piece-rate and overtime pay. These actions will increase labor costs, reduce the quantity demanded of labor, and reduce the U.S. production of labor-intensive agricultural products. Increases in labor costs will reduce head lettuce production and cause concomitant increases in the price of head lettuce and reductions in quantity demanded. Given that U.S. consumers already fail to consume the amount of vegetables recommended by the USDA, increases in labor wage rate regulations will exacerbate this deficiency."

Likely beneficiaries: Scientific community, stakeholders (local, state, tribal, national, international policymakers and agriculture labor industry), citizens (local, state, tribal, national, international agriculture employees)

Discovery
Change in knowledge</td><td></td></tr>
<tr><td>19</td><td>Integrated Pest Management depends on accurate identification and science-based recommendations.</td><td>Issue: The agriculture producers, residents, and visitors of Montana interact with nature frequently for economic and personal benefit. The Schutter Diagnostic Lab helps all types of Montanans identify pests of economic importance, invasive species, curiosities, etc. Accurate identification and subsequent diagnoses or recommendations help all clients implement science-based decisions with the least negative effect on the environment.

What has been done:
Schutter Diagnostic Lab
<u>Diagnosis Type Number of Diagnoses</u>
Plant Disease 944
Arthropods 792
Plant ID 437
Mushroom ID 32</td><td>Integrated Pest Management (4)</td></tr>
</table>

		Herbicide Injury 111 Other Abiotic Disorders 379 • Diagnoses supported 52 of Montana's 56 counties and the States of Arizona, Colorado, Idaho, North Dakota, and South Dakota • Social media posts had a reach of 82,000 with an average of 90 engaged users per post • 25 timely urban pest alerts were emailed to 480 professionals • 39 timely AgAlerts were emailed to 1,047 subscribers • The SDL is now testing mint mother stock and in-vitro plants for Verticillium dahliae. The absence of Verticillium is essential for mint growers to ensure that only healthy plant materials are distributed to customers. This year, SDL tested more than 300 samples. • Spider samples constituted 6% of all samples submitted and 45% of the home samples submitted. All diagnoses were followed with reports, which allowed for many clarifications of misinformation about spiders, particularly about the hobo spider and the brown recluse. **Results:** • Over $2.5 million was saved affecting approximately 1.1 million acres as a result of SDL recommendations. • 82% of survey respondents thought the SDL services were extremely or very useful in solving plant or arthropod-related problems. • 93% of survey respondents thought the timeliness of response was good or excellent. • 68% of survey respondents said the diagnoses and recommendations from the SDL influenced their management decisions. • Several new pathogens were detected, including Thielaviopsis spp. on lupine and field pea, Verticillium wilt on chickpea, and Erwinia bacterial blight on a South Dakota field pea sample.	

		• Old house borer, Hylotrupes bajulus (Coleoptera: Cerambycidae), was detected for the first time in Montana (Gallatin County) where imported eastern white pine timbers were installed throughout the home. • Confirmed three new county reports of plants that are problematic for agriculture in Montana [waterhemp (Amaranthus tuburculatus), Roosevelt County; Italian ryegrass (Lolium persicum), Judith Basin County; and common barberry (Berberis vulgaris), Fergus County]. • Collaboration with North Dakota State University led to the detection of Phytophthora spp. on chickpea samples from North Dakota; detection of the pathogen in our neighboring state will inform future disease monitoring in Montana. • Numerous samples were submitted to the SDL that were suspected to be affected by disease. In many cases, environmental or cultural factors are causing the plant stress, resulting in reduced health. Through collaboration of the SDL team with MSUE specialists, best management strategies are developed to effectively address the problem in an environmental-friendly way. • Several samples suspected to be invasive annual grass ventenata (Ventenata dubia) were submitted for identification, but only one was confirmed as the regulated plant, while most were native Montana grasses. Proper identification kept managers from mistakenly controlling beneficial plants, saving time and money and preserving native plant communities in Montana. ***Likely beneficiaries:*** *Scientific community, Extension professionals, stakeholders (local, state, tribal, national agriculture, horticulture and pest management professionals), citizens (local, state, tribal, national, international)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	

20	**First of its kind research studies wheat stem sawfly survival in different varieties of barley in Montana.**	**Issue:** Host plant traits strongly affect survivorship of insect herbivores, and host suitability is especially important for the wheat stem sawfly, Cephus cinctus, which spends its entire egg, larval, and pupal periods in a single stem. Measuring larval survival inside stems from egg hatch through diapause-mediated dormancy is a potential measure of population size for the next year but is also useful in assessing effects of growing season precipitation and temperature. Larval growth is synchronized with host plant growth, and the larva cannot switch hosts. Thus, incorporating plant physiological time, as growing degree days (GDD), may yield a better prediction of larval survival. Wheat stem sawfly survival was assessed from early larval growth to the beginning of autumnal diapause in barley cultivars selected from across feed, forage, and two- or six-row malt groups" Achhami, et al. (2020). **What has been done:** The Weaver research team conducted **"**field experiments in Gallatin and Chouteau counties, Montana, in 2016 and 2017. Kaplan-Meier estimation was used to assess larval survival among cultivars. It was found that the survival of pre-diapause larvae was greatest in 'Hockett' (36.5%) and lowest in 'Celebration' (15.4%). Precipitation and temperature during the growing season affected temporal patterns for larval survival across study sites. Adjusting survivorship curves using site-specific GDD accumulation allowed cultivar-specific survivorship to be estimated more precisely for each site, despite differing environmental influences. Findings suggest that measuring wheat stem sawfly survival across barley cultivars and standardizing by site-specific GDDs may provide better recommendations on barley cultivars that impede wheat stem sawfly population growth and reduce economic losses" Achhami, et al. (2020). **Results:** "For wheat stem sawfly larvae, final survival at the onset of diapause is the key factor affecting the rate of population growth for the next year because of the univoltine life cycle. Results suggest that wheat stem sawfly larvae in 'Hockett' had almost twice the final overall survival compared to larvae in 'Craft' and 'Celebration' from the same cohort... This is the first study	Integrated Pest Management (4)

		rigorously assessing wheat stem sawfly larval survival in barley cultivars. This work opens an area of study where predicting wheat stem sawfly populations in barley fields sown to particular cultivars is possible, with known weather patterns. The findings suggest 'Hockett' is the most suitable host for wheat stem sawfly populations in barley, an important consideration for Montana barley producers, because this cultivar is the third leading malting barley (AMBA 2020). Our recommendation is to plant a barley cultivar with lower larval survival in areas where highly damaging populations of wheat stem sawfly are evident" Achhami, et al. (2020). • Six undergraduate students were trained in this research • Three graduate students were trained in this research • Four journal articles were published. Achhami, et al. (2020a), Achhami, et al. (2020b), Achhami, et al. (2020c), Malone, et al. (2020). • Four conference papers were presented. ***Likely beneficiaries:*** *Scientific community, students, Extension professionals, stakeholders (local, state, tribal, national, international agriculture producers and professionals)* *Discovery, Engagement* *Change in knowledge, Change in Intention*	
21	**New tool will help predict Wheat Streak Mosaic Virus occurrences in the Northern Great Plains.**	**Issue:** Wheat streak mosaic virus (WSMV) is a sporadic disease in the Northern Great Plains vectored by the very small wheat curl mite. Symptoms include stippling or streaking of leaves, stunting, and yellowing. In the spring, symptoms can be easily confused with nutrient deficiencies. **What has been done:** With funding from the USDA-NIFA, the Burrows research team has built an online tool for predicting the risk of WSMV in the Northern Great Plains. **Results:** This predictive tool is being beta tested with a number of groups and is available for evaluation from other users. It is anticipated that the tool will	Integrated Pest Management (4)

		be made publicly available in collaboration with Kansas State University's MyFields project in the near future. • Three undergraduate students have been trained in this research, one of whom co-authored a manuscript • Three graduate students have contributed and learned through this research. • Three post-doctoral researchers have led and learned through this research. • Seven journal articles have been published. • One invited 2018 webinar for an international audience received renewed attention in 2020. • One journal article has been accepted for publication. • Two books have been published. • One conference paper has been presented. • Two fact sheets have been updated. ***Likely beneficiaries:*** *Scientific community, students, Extension professionals, stakeholders (local, state, tribal, national, international agriculture producers and professionals), citizens (local, state, tribal, national, international consumers)* *Discovery, Engagement* *Change in knowledge, Change in Intention, Change in Behavior, Change in Condition*	
22	**Invasive weeds negatively impact Montana's range, wild, and agriculture lands. COA, MAES, and MSUE research, develop, and**	**Issue:** 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 in 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 COA, MAES, and MSUE work extensively to improve the integrated management of rangeland weeds in Montana.	Energy & Natural Resources (5)

	implement sustainable solutions to improve livestock, wildlife, and production capacities.	**What has been done:** 1. The Mangold research team has completed research at three sites in Montana studying the relationship between downy brome control, revegetation with native grasses, and use of a conventional herbicide. The team quantified the long-term outcomes of seeding perennial grasses into rangeland infested with leafy spurge. Research at six sites in Montana and one site in Wyoming were established to study a bio-herbicide (Pseudomonas fluorescens, strain ACKSS). 2. The Littlefield research team continues to conduct research and development efforts that discover and study implementation strategies for the use of arthropods as biological controls for invasive plant species. 3. In summer 2020, Judith Basin County MSUE partnered with the Montana Biological Weed Control Coordination Project on a 5-year study of Puccubua punctiformis, a naturalized rust fungus that attacks Canada thistle. Canada Thistle is a common noxious weed in the county, costing thousands of dollars to control and preventing thousands of acres of pasture and hay ground from reaching full forage production potential. Any type of measure that is cost-effective and offers a good degree of control has the potential to save each producer several hundred to several thousands of dollars per year depending on the degree of infestation. **Results:** 1. The Mangold research team learned that bluebunch wheatgrass density was higher with spring seeding dates compared to a fall seeding date. Specifically, spring herbicide application was more effective than fall application. Between the two seasonal applications, spring	

		herbicide reduced downy brome cover three-fold at one site. The results show that a spring herbicide application to control downy brome followed by spring seeding of bluebunch wheatgrass established a seasonal priority effect for bluebunch wheatgrass, resulting in its increased density and cover. Restoration practitioners have a more strategic and ecologically-based option with timing of herbicide application and seeding bluebunch wheatgrass based on the results of this study, which is promising for downy brome-infested range and pasture lands. Another research project confirmed that seeding native grasses in Montana was most effective in the late fall through early spring (April) over late spring (May). Furthermore, fall to early spring seeding increased a grass stand's resistance to invasion by downy brome. Fourteen years after seeding native grasses into leafy spurge, the most productive grass, bluebunch wheatgrass, was about 70% of total plant community biomass. Leafy spurge became less productive in all plots and seeded and non-seeded plots produced similar leafy spurge biomass 14 years after seeding. Although seeding did not have a direct effect on leafy spurge biomass, bluebunch wheatgrass reduced exotic grasses by about 85%. This study, combined with past studies, identified invaded habitats where seeded grasses have a good possibility of persisting as productive stands. The team's results found that the results from sites in Montana and Wyoming showed that P. fluorescens is not a reliable tool for controlling downy brome in the Northern Great Plains and Central Rocky Mountains. 2. The Littlefield lab implemented techniques for two Aceria mites for control of hoarycress and field bindweed with success. Study of efficacy of two control agents on Russian knapweed showed plots with lower	

		plant density and stunted plants. Work continues to validate whether the observations were caused by the biocontrol agents. 3. Puccubua punctiformis has the potential to control Canada thistle and increase the production of the pasture, hay, or crop land that may be affected. Reducing the competition for desirable plants is key to a high-producing forage crop. The potential for success is promising, and the inoculation locations in Judith Basin County will help researchers determine the feasibility of using this rust in widespread applications. ***Likely beneficiaries:*** *Scientific community, students, Extension professionals, stakeholders (local, state, tribal, national, international land managers, including agriculture), citizens (local, state, tribal, national, international)* *Discovery, Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	
23	**Increasing understanding of water and mineral cycles and collaborative research are discovering things that may result in major shifts in sustainability practices in agriculture and natural resource management.**	**Issue:** Management of the quality and quantity of Montana water resources is expected to be a common topic in public and political conversation for the indefinite future. The Montana legislature recently tasked the Department of Natural Resources and Conservation to update a comprehensive State Water Plan [Montana Department of Natural Resources and Conservation, 2015]. Prominent in the major recommendations of that plan are the section headings “Improve and expand efforts to quantify surface water supplies and availability”, “Integrate natural storage to benefit water supplies and ecosystems”, and “Support improvements to the Montana water information system”. “In dryland semi-arid agroecosystems, any precipitation not transpired indicates crop yield that is below potential. Precipitation that is partitioned to deep percolation can transport nitrate out of the root zone, reducing nitrogen use efficiency and potentially contaminating groundwater. To mitigate loss of crop yield to drought, the practice of chemical summer-fallow (suppressing plant growth for a full growing season with herbicide) has been common in	Energy & Natural Resources (5)

		semi-arid regions to store water for the following growing season. However, precipitation losses during fallow tend to exceed the amount of precipitation stored, and fallow tends to increase nitrate leaching" Sigler, et al. (2020) **What has been done:** 1. The Payn research team is conducting five research projects that address the scientific gaps needed to address the needs of the State of Montana. Their studies focus on upland mountain headwaters, the lowland intermountain basins, and the river-floodplain corridors. 2. The Sigler research team has studied and modeled the effect of soil depth, chemical fallow systems, precipitation events, and nitrogen movement in the soil. **Results:** These independent research projects benefitted from collegial interactions. The following researchers contributed to these efforts: Payn, Ewing, and Miller (MAES); Sigler and Jones (MSUE); and Maneta (Univ. of MT). 1. The Payn research team is contributing to a better understanding of the controls on water quality and quantity in Montana, with the ultimate goal to support more informed land management decisions necessary to sustain water resource availability across the state. The team is involved in efforts to use novel environmental sensors to explore the causes and effects of water quality issues and continues to develop software necessary to make use of the environmental signals provided by sensor data. In particular, the team is using award-winning carbon dioxide sensors developed by colleagues at the University of Montana to provide new insight into the role of streams and rivers in the carbon cycle and associated metabolic processes that strongly influence water quality. The results are revealing the sources of groundwater inputs and connection with stream flow generation sources along Hyalite Creek, a critical resource to municipal and agricultural water supplies in the Gallatin Valley. New data from the Judith River Watershed collected in the summer of 2020 is suggesting	

		influence of understudied riparian processes on nitrogen processing. Together, this work informs management practices that enhance nitrate mitigation across a landscape with water resources polluted by excess nitrogen. The Beaver Mimicry Stream Restoration Project helps inform how stream restoration projects should be designed to achieve goals related to hydrologic storage. The Upper Clark Fork River project is continuing a long-term water quality dataset necessary to understand the extended influence of a major river restoration on ecosystem processes and the ecosystem processing of metal contamination. 2. The Sigler research team "results combine field observations with modeling to capture key interactions among crop rotation, soil architecture, and weather in cropping systems of the northern Great Plains that incorporate fallow. This synthesis highlights opportunities to increase water and N use efficiency for enhanced sustainability of agricultural yields in these systems that can also contribute to protection of environmental quality. In northern Great Plains agroecosystems, increased soil water storage during fallow periods facilitates mineralization of soil organic N to nitrate, resulting in elevated soil water and nitrate pools until the following growing season. Simulations suggest that fallow years account for 55% of deep percolation and 43% of leaching, despite fallow years only representing 33% of the rotation. In this work, soils with z_f values thinner than 25 cm have mean precipitation storage efficiency values of zero and confer no water storage benefits to the crop following fallow, while facilitating nitrate leaching rates five to 16 times higher than thicker soils (z_f >100 cm). While there can be motivations for including fallow in rotation other than water storage, these areas… may be attractive candidates for conversion to perennial forage production or for annual cropping with lower N application rates. Future work to improve resolution and accuracy of mapped soil water holding capacity could be combined with this work to identify soils that produce low transpiration and	

		economic returns while producing high leaching rates. These land areas with thin soil could be a focal point of programs incentivizing conversion to perennial vegetation or continuous cropping, with a likely outcome of reduced nitrate leaching and improved economic returns for farmers" Sigler, et al. (2020). Collectively these projects have accomplished the following: • Two undergraduate students were trained in this research. • Four graduate students were trained and learned through these research efforts. • One journal article has been published. Sigler, et al. (2020) • Three journal articles have been submitted. ***Likely beneficiaries:*** *Scientific community, students, Extension professionals, stakeholders (local, state, tribal, national, international agriculture producers and professionals, land and water resource managers)* *Discovery, Engagement* *Change in knowledge, Change in Intention*	
24	**Molecular and applied research and public engagement all work to improve the success of pollinators.**	**Issue:** Insects, particularly bees, are crucial pollinators in food production worldwide. Wild and managed species contribute significantly to feeding the human population. Up to one-third of the honeybee population since 2006 is lost annually. Fostering healthy pollinator populations is a high priority for society. **What has been done:** The O'Neill research team developed a solution for individual farms that improves pollinator success, increases food production, and, potentially, is economically positive to neutral for the farmer. A three-year research project was conducted on four food producing farms, studying the impacts of native perennial flower strips on pollinator success and the economics of selling the wildflower seeds to offset the cost of installation and maintenance.	Energy & Natural Resources (5)

		The Flenniken research team partnered with researchers in Israel to survey for new viruses in mining bees and honeybees. The study collected more than 1,300 bee specimens from 14 sites in Israel. The Flathead Reservation FRTEP and Lake County MSUE offices initiated an afterschool program aimed at teaching American Indian youth about beekeeping. Lake County MSUE agent Homewood taught basic beekeeping, entrepreneurship, and the importance of pollinators. Flathead Reservation FRTEP agent Richey built the partnerships and helped lead educational events that were culturally appropriate. Learning opportunities migrated to Facebook Live during COVID-19. As this new project continues, it will teach tribal youth how to market and sell honey, as well as make bee-related products such as soaps, candles, and lip balms. **Results:** The O'Neill Research Team • Over 200 bee species utilized flower strips for foraging on a Montana farm. • Flower strips occupy less than one percent of the production field. • Flower strips provided food resources for bees while the crop was not flowering. • Conservative calculations indicate that a farmer can break even or profit from the gathering and retail sale of wildflower seed in small packets. • Redundancy (planting multiple wildflower species that seem to support the same bee species) is important to support wild bee species throughout the growing season and across the farm. • One undergraduate student was trained in this research. • One post-doctoral researcher contributed to and benefited from this research.	

		• Four journal articles were published. Delphia, et al. (2019a), Adhikari, et al. (2019), Hayes, et al. (2019), Delphia, et al (2019b), Burkle, et al. (2020). The Flenniken Research Team and Collaborators in Israel • Discovered a new virus of bees (Andrena associated bee virus-1). • By studying more bee and other insect species the results indicated that many honeybee infecting viruses infect other species as well. • The virus is not of immediate concern for bees. However, it provides an opportunity to improve understanding of bee-virus interactions and the immunity responses of bees. It also allows for study of virus interactions at the cellular level. This future research could inform strategies to mitigate colony losses. • This research allows members of MSU's Pollinator Health Center to study cellular and individual insect impacts of viral infections. • Two stakeholder and outreach presentations have been made. • Three invited seminars have been delivered. • Two student presentations have been delivered. • Three journal articles have been published. Daughenbaugh, et al. (2021), Faurot-Daniels, et al. (2020), McMenamin, et al. (2020). ***Likely beneficiaries:*** *Scientific community, students, Extension professionals, stakeholders (local, state, tribal, national, international pollinator service industry), citizens (local, state, tribal, national, international consumers)* *Discovery, Engagement* *Change in knowledge*	
25	**It is important to understand and test assumptions on interactions between wildlife**	**Issue:** Montana ecosystems support many wild and human activities. Management of these systems is complex and often the trade-offs between these services (e.g., habitat for wildlife, plant biodiversity, water quality, and resistance to soil erosion) are not well understood. Decisions about the timing and intensity of livestock grazing interacts with plant populations, gamebirds,	Energy & Natural Resources (5)

	and domestic grazing animals.	predators, and more. MAES researchers in the Animal and Range Sciences Department have completed several studies that help improve the understanding how different components of these systems influence each other. **What has been done:** The McNew and Sowell research teams evaluated how female sage-grouse selected nesting habitats in a sagebrush steppe on grazing land that also included human introduced structures that may influence hiding cover, microclimate, predator travel routes, and perches. In another study the McNew research team explored aspects of sharp-tailed grouse nesting habits when interacting with grazing livestock and associated agriculture improvements. The research team has also studied monitoring strategies utilized by wildlife managers. **Results:** The teams discovered that cattle grazing had no effect of sage-grouse nesting habits. They did observe that nests closer to fences and other human introduced structures had a lower survival rate. However, predation was reduced when cattle were present. They speculate that the presence of the cattle or visits by ranchers to provide supplements discouraged predator presence. In another study they learned that alternative or innovative grazing strategies did not improve gamebird survival rates. Their study of gamebird carcasses provided provisional evidence that scavenging can significantly confound field-based determination of cause of death. This study can help wildlife managers avoid errant data interpretation. Three journal articles have been published. Cutting, et al. (2019), Milligan, et al. (2020a), Milligan, et al. (2020b) ***Likely beneficiaries:*** *Scientific community, students, Extension professionals, stakeholders (local, state, tribal, national, international land managers and*	

		regulators, including agriculture), citizens (local, state, tribal, national, international outdoors recreationists) *Discovery* *Change in knowledge*	
26	**Youth Aware of Mental Health Program Engages Youth in being Healthy Mentally.**	*This report is representative of the successes many local offices had during 2020.* **Issue:** Montanan's are increasingly identifying mental health as an important issue for their communities. MSUE's Youth Aware of Mental Health (YAM) works with youth to teach them that mental health is as important as physical health. In 2013-2017 Montana had 11.8 suicides per 100,000 in youth ages 11-17, almost three times the national average. The 2019 Youth Risk Behavior Survey documented that 10% of 9-12 grade students have made a suicide attempt. **What has been done:** The YAM program has been implemented with middle and high school students in counties and on reservations across Montana. YAM is a five-session program covering the basics of mental health and offering youth the opportunity to role play tough situations. This class covers challenging topics like drug use, parents fighting, depression, and relationship breakups. Participants think about the hypothetical situations before experiencing them. For example, it helps students to know that everyone feels uncomfortable when parents or guardians fight. Students brainstorm positive things to do to feel better. The class focuses on the importance of self-care for mental health, what to do to feel better, what depression is, and how to know when a friend needs help. **Results:** Flathead Indian Reservation Extension FRTEP implemented YAM in two schools. One result was the formation of an in-school Youth Mental Health Leadership 4-H Club. Members of the club are partnering with a coordinator to	Youth & Family Development (6) Healthy Living, Nutrition, & Food Safety (7)

		develop a public awareness campaign addressing social, emotional, and physical health and wellness. The youth have organized, developed an action plan, and are implementing their plan. The youth have been innovative and have worked to include isolated members during the limitations of COVID-19. Liberty County YAM students began to recognize the need to think through different stress and crisis situations and understand the importance of mental health. Students have also initiated conversations with their peers about mental health. Students made the following class observations: • "I learned how to tell/help people that are depressed." • "I learned coping mechanisms for stress and depression." • "I learned there is always someone there for you." • "I learned how to help others feel better about themselves." • "I learned different situations people might be put in and how they get out of it." • "I learned that reaching out is better than hiding your feelings even though you might not have the strength." In Park County's Youth Aware of Mental Health (YAM) program, 128 Park County freshman were able to have candid discussions with classmates about issues they face and to brainstorm solutions. One student shared "I learned about drugs from my mom. There were some drugs she used that she would be okay with; still my mom. Other drugs made her crazy. She finally just left. That was six years ago. I think you all need to know that about me." Most importantly, community, state, and national resources are discussed and tried. Students put the National Crisis Hotline and Text Line numbers into their cell phones. Then at least one of them tests the numbers immediately. It helps to hear there is a real person at the end of the hotline and a real person on the text line. They know resources are a button away if they or a friend ever needs them.	

		Teton County's YAM program reaches approximately 80 students per year and is offered to every ninth-grade student in public school in Teton County. MSUE Agent Wolery also teaches the "Question, Persuade and Refer" suicide prevention program to school faculty. 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. • Nearly half of students reported they would seek help from school staff for assistance with feelings of suicide. • 79% said they would seek help for depression. During the first weeks of the COVID-19 pandemic, Wolery focused media outreach on mental health resources, such as Thrive for Montana, an online cognitive behavior therapy, and the Montana Ag Producer Stress Resource website. ***Likely beneficiaries:*** *Extension professionals, stakeholders (local, state, tribal, educators and youth serving professionals), citizens (local, state, tribal)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior, Change in Condition*	
27	**Youth Citizenship and Leadership**	**Issue:** Montana's youth can strengthen their communities through 4-H. **What has been done:** 4-H programs empower youth to be well-informed citizens who are actively engaged in their communities and the world. Youth build decision-making skills and develop a sense of understanding and confidence in relating and connecting to other people. Almost 3,800 Montana 4-H members enrolled in leadership-based projects. **Results:**	Youth & Family Development (6)

		Leadership projects for youth result in character development, personal growth, goal setting, and empowered youth who led efforts to address community needs with positive impact. Over 44% of 4-H youth in grades 7-12 surveyed credit their 4-H experience for providing a greater opportunity to learn about people who are different from them. Over half of grades 3-6 4-H members indicated they had more opportunity to help plan a community service project since joining 4-H, while 24% reported having led a community service project as a member of 4-H. One 4-H member shared "I have participated in multiple presentations, from one person in the audience to hundreds. If I had not done 4-H I would not have [had] these opportunities to develop my speaking and listening skills." ***Likely beneficiaries:*** *Citizens (local, state, tribal youth, parents and volunteers)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior, Change in Condition*	
28	**COVID-19 especially impacted people providing long-term care to loved ones. Cascade County MSUE met these needs when stress levels for caregivers went to a new level.**	*This report is representative of the successes many local offices had during 2020.* **Issue:** COVID-19 and the associated shelter-in-place and other restrictions impacted the nation beginning in March. All of the COA, MAES, MSUE and our clientele responded to these changes with innovation, adaptation, and success. For local MSUE offices, our high-touch interactions with clientele stopped overnight. **What has been done:** Extension professionals and clientele were able to rapidly adopt and accept distance and virtual approaches to continuing the	Youth & Family Development (6)

		vital local relationships and interactions. Virtual meeting tools, social media, websites, and appropriate and safe in-person interactions became the norm with great effect. These adaptations are present across all MSUE disciplines. **Results:** Implementation of social media and virtual strategies met clientele needs in a timely manner. These social media also reached beyond the locally bound clientele to regional, multi-state, and international audiences in some cases. One example of this is how Cascade County MSUE agent Finch supported long-term, volunteer caregivers during COVID-19 restrictions. In challenging times, clientele often find themselves giving to others while dismissing their own need for self-care and support. Powerful Tools for Caregivers is a nationally-known program that empowers and encourages caregivers caring for loved ones to add self-care tools to their daily lives. Finch, a Family and Consumer Sciences Agent, partnered with Jona McNamee, retired MSUE agent to offer four Powerful Tools for Caregivers classes to 22 participants. This program was a success despite social isolation and the limitations of adhering to COVID-19 restrictions. It offered caregivers the opportunity to connect with other caregivers, and to learn and develop a support system within their community. The series provides tools to improve confidence, handle emotions, communicate through difficult situations, and most importantly, improve self-care. Caregivers often find the physical resources they need to help during the caregiving experience like medical care, but it is the social aspects and isolation that is often more challenging. • One caregiver reported "I was able to give myself permission to take care of me for once." • Over 80% of caregivers shared that they learned a new skill and will continue to practice self-care through a physical activity such as walking. • Caregivers also reported they felt more connected knowing they were not alone in caregiving feelings, challenges, and obstacles. • All participants reported increased self-esteem knowing they were not alone.	

		Caregiving is a tireless job and learning about resources for self-care through the Powerful Tools for Caregivers program allows caregivers to continue to meet the needs of loved ones with the utmost care and concern for their loved ones. ***Likely beneficiaries:*** *Citizens (local, state, tribal voluntary caregivers)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	
29	**Fort Peck FRTEP office honors culture and teaches youth STEM, food science, nutrition, and teamwork.**	**Issue:** The Fort Peck Reservation FRTEP develops youth practical and leadership skills which are tied to their cultural buffalo herd. **What has been done:** Fort Peck Reservation MSUE received a portion of funds to house an intern and work with school classes to teach about using buffalo meat in sausage and jerky making. There were eight classes totaling 75 students that participated at two schools. An intern enrolled in the Fort Peck Community Project and funded through the Chante Program helped choose a project to work with the students to guide learning and provide relevant information from the Fort Peck Tribes Buffalo Project and Buffalo Treaty. **Results:** Students learned about the health aspects of consuming buffalo meat, differences in cooking practices for buffalo, price differences, and what buffalo eat that affects their meat. For the hands-on portion of class, students paired up and created a recipe for their final project. They cut and ground meat, used two types of grind settings for proper consistency and added spice mixtures. After resting overnight, meat was cased into sausage or dehydrated for jerky. It was wrapped, packaged, and labeled for the final product. Students were able to take home what they had created. Youth connected the buffalo meat processing with their culture, the program was centered around the Montana Indian Education for All initiative. Youth learned the importance of accurate calculations of spices and understood proper kitchen, equipment and food	Youth & Family Development (6) Animal Sciences (1) Healthy Living, Nutrition & Food Safety (7)

		safety. They reported understanding many more new aspects of buffalo meat than they did before and learning other uses for the meat. ***Likely beneficiaries:*** *Citizens (local, tribal, youth and families)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	
30	**MSU Estate and Legacy Planning Educational Classes and Resources Save Montanan's Money Year After Year.**	**The Challenge** • **70%** of Montanans die without a will • **92%** of participants did not know who would receive property under Montana law if they died without a written will. • **75%** did not know Montana eliminated the inheritance tax in 2001. • **77%** did not know a will has to pass through probate to be declared legal. • **96%** did not know how property passes in a married couple situation when held in sole ownership by one spouse. **What has been done:** • Montana families/individuals were taught about the potential consequences to their family's wellbeing when they let state law determine their heirs. • Collaboration with the Business, Estates, Taxes, Trusts, and Real Property Section (BETTR) of the State Bar of Montana to develop MontGuides (fact sheets) with legally accurate information about state and federal laws impacting estate planning goals. • Empowering Montanans to assure family wellbeing by attaining their estate planning goals and empowering them to pass assets to their beneficiaries without a costly probate. • 1,771 Montanans purchased Estate Planning: The Basics Packet packets. Their names were added to a mailing list to receive updates when state or federal laws change. • 46 Estate Planning MSUE MontGuides or Fact Sheets published.	Farm, Ranch, and Business Management (3) Youth & Family Development (6)

		• 1,383 Requests for Dying Without a Will CD from 2010 – 2020. • 36,275 hits on the **Dying Without a Will Website** from 2010 - 2020 • 271 estate planning presentations from 2016-2019 • 8,248 participants attending from 2016-2019 **Results:** As a result of attending MSUE estate/legacy planning programs, participants reported they accomplished the following: • 69% Added payable on death designations and transfer on death registrations to their financial accounts. • 65% Reviewed ownership titles on their financial accounts. • 62% Reviewed an existing will. • 59% Discussed estate planning with a spouse. • 49% Reviewed beneficiary designations on their stocks, bonds, and mutual funds. • 46% Discussed estate planning with adult children. • 38% Made an appointment with an attorney to have a will written or revised. *Participant Learning and Changed Behaviors:* • "Used information to set up my mother's affairs." • "Made beneficiary deeds on home and business. Made financial and medical power of attorney documents." • "Helped elderly parents review their estate plan." • "I had questions about going through probate for my parents [sic] estate. Although I was living in Las Vegas at the time, I could not have been more impressed with the help I received." • "Thanks [sic] it was good to learn all Montana's requirements and laws. I had it all wrong. Thanks Again." • "I'm so relieved the workshop helped me so much in understanding the process. Thank you. I recommend it to everyone." • "Filed homestead declaration. Completed financial and health care POA."	

		Likely beneficiaries: *Extension professionals, stakeholders (local, state, tribal, estate planning related professions), citizens (local, state, tribal residents)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	
31	**Personal Finance: MSUE and NDSU partner to provide long-term, persistent, individual, and family finance education online.**	**Issue:** Montana median household and per capital incomes are below the national medians and the median owner-occupied home is well above the national median. These facts combined with consumer debt, individuals with lower financial acumen, and easily accessed loan and credit tools contribute to financial stress. **What has been done:** Since 2011, over 6,500 educational hours of free, unbiased, research-based information addressing investing, retirement, student loans, credit scores, estate planning, financial fraud, budgeting, and mortgages have been provided to people in 43 states. **Results:** **Participants had this to say following completion of a class:** • "It is never too late to make changes to how you handle your money" • "I will make retirement more of a priority, instead of putting it last." • "When my son's financial aid package arrives, I feel like I will be able to decipher what it all means and make an educated decision on accepting it or not. Thank you." • "I really appreciated the information on credit scores and Banking 101." **Of participants who responded to surveys…** • **100%** have taken steps to **improve their health or finances** • **94%** took steps to protect themselves against identity theft • **88%** created or added to an emergency savings fund • **86%** have created a debt management plan • **73%** have taken steps to avoid being a victim of a financial scam • **71%** have determined ways to cut their spending	Youth & Family Development (6) Farm, Ranch, and Business Management (3)

		Likely beneficiaries: *Extension professionals, stakeholders (local, state, tribal, national, employers), citizens (local, state, tribal, national)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	
32	**Strong People: Strength Training Program**	**Issue:** Many Montanans struggle with living healthy lives. Strength training is now proven to have positive impacts on health and independence. **What has been done:** Strong People®, an evidence-based, 12-week program is provided by MSUE in several counties and reservations. Strong People® helps participants increase their joint flexibility, muscle strength, balance, and overall well-being. **Results:** 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% strengthened 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. Participants in Big Horn County showed increased strength, balance, stamina, and the ability to move freely and easily. Participants increased community ties and reported decreases in stress and anxiety, with a significant increase in	Healthy Living, Nutrition, & Food Safety (7)

		sleep. As a testament to program benefits, many participants continued to exercise at home during the shelter in-place restrictions for older adults. In Sanders County, those who attended the sessions twice a week for two to four months reported moderate to considerable improvements in general health and balance, feeling stronger physically, doing everyday activities more easily, increasing weight they are able to lift, and flexibility. Sanders County partnered with Clark Fork Valley Hospital to offer people of all ages this opportunity to improve their quality of life. Seventy-two people have participated in classes hosted both in Thompson Falls and Plains during 2020. ***Likely beneficiaries:*** *Extension professionals, stakeholders (local, state, tribal health and social support organizations), citizens (local, state, tribal participants)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	
33	**Determining Opioid and Prescription Drug Misuse and Training Community Leaders to Help the Affected**	**Issue:** An estimated 36,000 Montanans misused prescription pain relievers and 6,000 had Opioid Use Disorder each year from 2017-2018 (SAMHSA, 2019). In 2017, deaths from drug overdoses in rural areas surpassed rates in urban areas. Nearly 50% of opioid-related deaths in Montana are people aged 45 and older. **What has been done:** MSUE conducted a statewide online survey targeting adults ages 45 and older in rural areas of Montana. Of survey respondents: • 65% state that prescription opioid misuse is a problem in their community • 52% state they know someone who has misused prescription opioids • 78% said they would likely use a prescription take-back box if one was available in their community • 58% mentioned they would utilize a medication disposal pouch if one were made available to them	Healthy Living, Nutrition, & Food Safety (7)

		• 72% reported they would be likely to share information about the dangers of opioid use with their age-appropriate children **Results:** MSUE has provided Technical Assistance Training on opioid misuse to 120 people from 5 counties and 9 tribal communities, has supported five Tribal Opioid Misuse Strategic Planning sessions, and has gathered opioid information from six community focus group sessions. MSUE has distributed 1,231 Deterra Medication Disposal Pouches and over 12,000 opioid awareness and educational materials across Montana. ***Likely beneficiaries:*** *Extension professionals, stakeholders (local, state, tribal, support and enforcement agencies), citizens (local, state, tribal)* *Discovery, Engagement* *Change in knowledge, Change in Intention*	
34	**MSUE Helps People in 10 counties and four reservations increase healthy eating habits in the context of diabetes.**	**Issue:** About 64,000 Montana adults currently have diabetes. Montana adults with diagnosed diabetes increased from 2.9% in 1990 to 6.4% in 2019. Diabetes is more common among American Indians/Alaska Natives adults than white, non-Hispanic adults in Montana. In 2019, 14.9% of American Indian/Alaska Natives adults in Montana reporting having diagnosed diabetes compared to 5.8% of white non-Hispanic adults. **What has been done:** • 92 Montanans in rural communities participated in this pilot program. MSUE held courses in these counties: Toole, Hill, Valley, Richland, Custer, Big Horn, Cascade, Teton, Sanders, and Mineral. **Results:** • The participants learned to *manage diabetes* for themselves or a family member *through nutrition education*. • Participants learned more about *non-starchy vegetables and healthy fats*.	Healthy Living, Nutrition, & Food Safety (7)

		• They also learned to *prepare healthy, well-balanced meals* that taste good. *Healthy Behaviors by the End of the Program:* • 100% of participants reported they learned to *read and understand food labels* and *choose diabetes-friendly recipes*. • 98% learned strategies to *modify or substitute foods* to make their meals healthier. • 96% are now *eating 3-5 fruits and vegetables daily*. • 93% are eating *smaller portions*. • 89% are *cooking more* meals at home. • 88% are choosing beverages with *less sugar*. *Participants had this to say following the class:* • "I'm more aware of food labels and am paying much more attention to them." • "The "trick" to reading labels was very helpful." Big Horn County Increased engagement in partnership with Helping Hands In Hardin Food Pantry. MSUE helped in developing and distributing a monthly newsletter to approximately 300 households served by the food pantry. This serves the people of the county and the Crow Indian Reservation. ***Likely beneficiaries:*** *Extension professionals, stakeholders (local, state, tribal, health and social service agencies), citizens (local, state, tribal)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	
35	**Improving Healthy Life Choices for Limited Resource Families and Individuals with SNAP-Ed and EFNEP**	**The Challenge** • **72%** of Montana youth do not participate in enough aerobic activity to meet guidelines • **63%** of Montana adults are overweight or obese • **92%** of Montana adults do not meet vegetable intake recommendations	Healthy Living, Nutrition, & Food Safety (7) Youth and Family

	Partnerships with USDA and the State of Montana.	• **72%** of American Indian adults are overweight or obese • **26%** of Montana children ages 10-17 are overweight or obese • **11% of** Montanans face hunger or food insecurity **What has been done:** Low-income youth and adults are offered classes in the locations that they eat, live, learn, work, play, and shop. Collaboration with communities and statewide partners to leverage resources and increase program reach to eligible audiences. Empowered organizations and individuals to create changes in policies, systems, and environments that make the healthy choice the easy choice for all Montanans. *EFNEP* • 1,273 youth participants in *Youth Understanding MyPlate* series • 316 adult participants in *Eating Smart Being Active* series • 914 adult and youth graduates • 609 nutrition and physical activity classes held *SNAP-Ed* • 21,509 Montanans reached with education or environment changes that assist in making the healthy choice the easy choice • 4,848 youth participants reached with nutrition and physical activity classes • 523 adult participants reached with nutrition and physical activity classes • 193 partnerships with organizations where Montanans eat, live, learn, work, play, and shop • 99 policy, system, environment, or promotional changes to support health *Social Media Outreach for Both Programs* • 6,382 visits to buyeatlivebetter.org • 34,711 Pinterest and 25,635 Facebook views **Results:**	Development (6)

		EFNEP **48%** of adult participants ate fruit more often **50%** of adult participants ate veggies more often **77%** of adult participants were more physically active **79%** of adult participants improved food safety practices **82%** of adult participants improved food management practices **41%** of youth participants improved physical activity practices **49%** of youth participants improved food safety practices **89%** of youth participants made healthier food choices **A first grade student learned about food groups during our EFNEP nutrition classes.** Her mother reported that she was excited to make the recipe on the newsletter that came home each week. When cooking the recipes with her mother the student confidently makes sure that each meal contains all of the food groups, and she is even willing to try new foods. - Nutrition Educator **EFNEP helps a young couple learn to incorporate more fruits and vegetables in their meals.** A young couple, with their six-month old, took part in a series of healthy cooking and nutrition classes in Central Montana. They did not have transportation, but diligently attended all nine classes. They enjoyed learning how to incorporate more fruits and vegetables into their meals,adding vegetables to pasta sauce, or fruits and vegetables to smoothies. Their confidence in cooking grew throughout the series and they expressed feeling more comfortable trying new ways to cook, including making their own baby food using fresh vegetables and fruits. **Montana State University Extension's Nutrition Education Program is a program partner with several statewide organizations working to offer and promote the use of Double SNAP dollars at farmer's markets across the state.** Through the statewide partnership, local EFNEP programs provide education on use of farmer's markets, and are able to offer coupons for free fruits and vegetables to adult EFNEP participants who want to use their EBT cards at a local market. Through this partnership,	

		EFNEP is helping participants stretch their limited food dollars and increase access to fresh fruits and vegetables. **A young, single mother enthusiastically completed a nine-week series of EFNEP classes where she learned to stretch food dollars by planning healthy, cost effective meals each week.** She also learned how to incorporate more fruits and vegetables into meals she cooked for herself and her two-year-old daughter. She looked forward to grocery shopping because she learned how to read food labels, which made it easier to make healthier choices. She was getting ready to move into her first apartment and was excited to use all of the incentive items, which included measuring cups, measuring spoons, a refrigerator thermometer, and a fruit and vegetable brush. Additionally, she discovered that she could easily fit daily walks with her daughter into her schedule in order to get more exercise each day. *SNAP-Ed* Adults **47%** ate fruit more often **48%** ate veggies more often **66%** were more physically active **72%** improved food management practices **82%** improved food safety practices Youth **49%** improved physical activity behaviors **55%** improved food safety practices **88%** made healthier food choices Program Impacts • 99 nutrition and physical activity improvements in SNAP-Ed counties or reservations • 27 school-based Harvest of the Month partnerships that promote healthy Montana foods • 11 food bank partnerships that increase capacity for healthy choices	

		• 9 farmer's markets with increased access to and promotion of fruits and vegetables **In Northern Montana, SNAP-Ed partnered with educators to teach youth how to grow and prepare healthy produce.** Youth nutrition classes were paired with a school garden program. Students enjoyed learning how to prepare soil and plant seeds. Students then learned to how to properly harvest tomatoes, zucchinis, dill, basil, and beans, which they used to prepare fresh salsa. **In Southwestern Montana, SNAP-Ed helped increase healthy food access and consumption.** SNAP-Ed facilitated a multi-agency partnership that resulted in the acceptance of SNAP dollars at a farmer's market that serves several low-income neighborhoods. One shopper learned about this opportunity while attending a SNAP-Ed nutrition class and was excited to report that she was better able to access healthy, affordable food as a result. This partnership has also benefited local farmers. **In Southern Montana, SNAP-Ed collaborated with a food bank to better meet the needs of the community.** Following a Healthy Food Pantry Assessment, SNAP-Ed helped the food bank develop short- and long-term goals for improvement, such as adding garden space, volunteer training practices, and nutrition-focused signage in both English and the indigenous language. ***Likely beneficiaries:*** *Citizens (local, state, tribal)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior, Change in Condition*	
36	**Teaching People to Identify and Respond to Signs of Mental Illness or Substance Use**	**Issue:** Mental health related surveys indicate: • **36.7%** felt sad or hopeless • **23.4%** seriously considered suicide • **10%** had attempted suicide	Healthy Living, Nutrition, & Food Safety (7)

	Disorders – Mental Health First Aid (MHFA)	• **163,000 Montanans** ages 18 and over had a diagnosable mental illness* • **80,000 Montanans** ages 12 and over had a substance use disorder* **What has been done:** MHFA is designed to increase knowledge and build skills to help someone who is experiencing mental health problems. The training includes information about signs and symptoms of mental health problems and provides opportunities to practice response skills for specific types of problems. Mental Health First Aiders were trained to respond in supportive ways to someone experiencing a mental health problem, as well as suggest and connect people to community resources, especially professional help. **Results: 301** Montanans were trained: **115** in Youth MHFA and **186** in Adult MHFA. MHFA Courses were taught in 13 counties and reservations. ***Likely beneficiaries:*** *Stakeholders (local, state, tribal health and social service agencies), citizens (local, state, tribal)* *Engagement* *Change in knowledge*	Youth and Family Development (6)
37	**MSUE Develops Montana Ag Producer Stress Resource Clearinghouse to Provide 24/7 Resources to the Agriculture Community.**	**Issue:** Caring for a farm or agri-business is hard work. Farmers and ranchers tackle the essentials of caring for and managing animals, crops, and employees every day. At the same time, ag producers often deal with work-related family dynamics, climate and seasonal issues, or financial stressors, such as changing commodity prices. MSUE has sought input from agricultural organizations, educators, health professionals and local Montana farmers and ranchers to identify the specific situations causing stress, and to put together a set of tools to help our Montana agricultural community better manage and cope with the stressors they might be experiencing. The aim is to provide helpful information to farmers and ranchers, rural or subsistence farmers, in addition to their family members and loved ones with online resources. The site helps to	Healthy Living, Nutrition, & Food Safety (7)

		identify the circumstances that cause stress in daily life, measure stress, teach how to manage stress, and connect users to resources for individualized assistance. **What has been done:** MSUE Family and Consumer Sciences specialists Michele Grocke and Alison Brennan built a partnership with the Montana Healthcare Foundation to accomplish the following goals. • Develop the **Montana Ag Producer Stress Resource Clearinghouse** website. • Formed the Montana Farm/Ranch Stress Prevention Advisory Council with membership representing agriculture member associations, tribal communities, county government, state agencies, USDA FSA, MSUE Local Government Center, and MSU Department of Health & Human Development. **Results:** • Responding to People Under Pressure Under the Big Sky was published, with 5,000 copies distributed • Created and published a "Distress Map" to guide people helping a distressed person. ***Likely beneficiaries:*** *Extension professionals, stakeholders (local, state, tribal, national, international), citizens (local, state, tribal, national, international)* *Engagement* *Change in knowledge*	
38	**Leadership Development in Montana's Rural and Frontier Communities**	**Issue:** Rural and frontier counties consistently identify the need for new leaders in their communities. These counties need 1 in 8 to 1 in 20 citizens to take on leadership roles in government, non-profits, or private community-minded entities. A decade ago, the MSUE agents in Park County built trust with key community leaders, collaborated with Wyoming Extension Community Development agents, and led the development of an eight-month leadership	Community Development (8)

		program, Leadership 49. Now in its seventh year, the long-term impact of the program is being measured. **What has been done:** • Leadership 49 was created with an advisory committee of community leaders from across Park County. • Six Leadership 49 classes have graduated 100 participants, which will increase to 118 alumni April 2021. • Participants have experienced a total of 48 Community Based Experiences where they learn about communities and issues throughout this geographically large and diverse county; spanning from the Northern and Northeastern Gates of Yellowstone National Park to traditional ranches and farms in the northern part of the county. • Leadership 49 educational strategies and materials are continually adapted and updated to fit the immediate needs of the people in Park County by a planning team made up of program alumni. • Extension, community, and other experts in leadership have led participants in developing leadership skills. **Results:** Over the first six cohorts, participants have reported the following: • 100% of participants better understand themselves. • 100% are or will contribute to the enhancement and sustainability of their community. • 100% increased their network or connection with people or leaders. • 100% will promote positive impacts for the people of Park County. • 98% have a greater understanding of county-wide opportunities and challenges. • 97% Have a greater appreciation for the differences in others. • 95% feel prepared to facilitate, mediate, and effectively engage in community-based conversations. • 95% are able to foster and facilitate positive cultural change.	

		• 94% feel better prepared to persevere and exhibit resilience in the face of adversity. • 85% of participants say they have become a better leader. • 56% have helped improve the effectiveness of meetings and actions of boards or committees. What participants say about how they benefitted from Leadership 49: • "The skills that taught me how to collect ideas, recognize and organize a team with a goal in mind and the process to bring that team to a final goal. Including things such as the sticky notes of ideas on a board, the dots, how to keep a group on task, as well as the dynamics of a group." • "I think for me it was being able to listen to different perspectives from fellow participants. " • "Connecting me with the challenges and opportunities in the county that I had no idea about has helped me brainstorm how I can use my skills and passions to be a leader in the community." • "In combination with some other experiences this year, I see that there is a place for me in a leadership role or that I am capable of this. It has made considering applying to formal leadership roles in the county more accessible, in part because it took away some of the mystery of the process and introduced me to the real people in those roles. If we all have something to contribute to this county as a leader, then that means I have something to contribute. I can do this." • "Exploring the entire county, understanding each communities' strengths and weaknesses and how to get involved." • "It was a year full of self-discovery and discovering more about not only the community I lived in but the experiences and lifestyles of rural America." • "I believe that I benefited the most from being pushed outside of my comfort zone in certain situations and was challenged to address problems or potential issues head on. To utilize what we learned rather than resort back to the default behaviors that I may have had prior to the program."	

		• "Thank you so much for the opportunity to be part of this experience. I look at this as the start of a continuing process that will grow and change over time. I built lasting relationships and learned so much about myself. You guys do an amazing job!" • "I am more mindful of the differences in personality and generations. I work hard to put myself in other's shoes in order to work better together. I now understand my strengths and weaknesses better in order to push myself to be that better person and leader." • "I found the personal growth portions of the program to be most beneficial to me. I didn't used to think what I did mattered but I see now that's not true. I really got a lot of confidence in my skills and strengths and I feel I understand how to use them more effectively." • "I found that discussion and lessons around how to have and navigate through difficult conversations has been most beneficial to me. A lot of the conversations I have for work are high emotion because the topics can include compensation, leave from work, benefits, and potential termination of employment. I find myself looking back through notes and my binder from our sessions frequently." • "Leadership 49 was a way for me to explore growth and development in a safe setting with fellow humans navigating this crazy life." • "The conversations about politics and personal stories over lunch were very powerful to me. It was a completely different mindset than I had ever been in around other adults. It was very humanizing." • "Such powerful community-building/connecting! As a new resident to Park County, this program was invaluable -- I feel deeply invested and committed to being a better community member. L49 is a major reason why Park County really feels like home." • "L49 was a transformative and pivotal experience in my Park County journey, and I'm so grateful to have participated early in my time here so I can thoughtfully contribute and invest in this community. Such an incredible head/kickstart!"	

		• "Sometimes leading means knowing when to step back. Leaders do not need to be loud." **Expansion** Leadership 49 began to address local needs, benefitting from the previous work by Wyoming Extension's EVOLVE program. In recent years a team of MSUE Community Development and other agents have expanded the relationship with Wyoming Extension and learned from the experiences in Leadership 49 and developed a robust Leadership framework that will be implemented in counties across Montana. Four additional counties now have similar leadership programs and agents in other disciplines are being trained to lead community-based leadership programs. Early results in these counties have individuals being inspired to share what they learned about leadership with others, taking on community leadership roles, and pursuing partnerships that strengthen their communities. ***Likely beneficiaries:*** *Extension professionals, stakeholders (local, state, tribal, leadership), citizens (local, state, tribal)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior, Change in Condition*	
39	**Reimagining Rural: A Research Driven Partnership to Help Frontier Communities Envision and Seek a More Vibrant Future.**	**Issue:** Across the state of Montana, some rural communities have experienced declining population, reduced enrollment in schools and closures of main street businesses. MSUE enlisted help from University of Minnesota Extension's Center for Rural Vitality's expert, Ben Winchester and built in-state partnerships with the Montana Community Foundation, the Governor's Office of Economic Development, and the Burton K. Wheeler Center at Montana State University. The partnership created the Reimagining Rural Program to raise awareness of rural issues and to advance the conversation about a vibrant future for rural Montana.	Community Development (8)

		What has been done: • Over 100 people gathered in Harlowton in the fall of 2019 to build enthusiasm and relationships with rural citizens, interested organizations, and leaders. • Due to COVID-19 restrictions on travel and gathering MSUE conducted focus groups that found strong support and increased need during COVID-19 to continue the program. • Reimagining Rural virtual programs were held with 24 communities participating. Three sessions were held in fall 2020 addressing the topics of "Rewriting the Rural Narrative", "Save Your Town", and "Increasing Community Vitality." **Results:** • Winchester's analysis indicates that Montana has a leadership demand of 1 in 22 adults needing to be in a community leadership role, which opened the eyes of rural citizens and leaders to the need. It also confirmed what others were already observing. • Participants in the initial session indicated they had negative attitudes about their rural communities. These positions were not supported by the data analyses presented by Winchester. They were encouraged to see that migration trends have positive aspects for rural communities. • Some participants are interested or concerned about finding the appropriate balance between maintaining traditions and embracing change that occurs when demographics evolve. • The second session in fall 2020 focused on action planning. This session helped communities develop ideas for local projects and making positive progress. The local participants built enthusiasm and excitement about beginning to move toward strengthening their communities. • Participants were encouraged to plant a flag and were given permission to try something and that if it didn't work, that was okay. This is an important	

		mindset as fear of failure or the desire for perfection is a barrier to initiation of new projects. • The final session was a capnote by an innovative female entrepreneur who started a business (Red Ants Pants) in White Sulphur Springs, Mont. Her story is inspirational and demonstrates the difference one person can make in a rural community. Participants indicate that her story was inspiring. • This program will continue into the future and further evaluation and follow up will continue. ***Likely beneficiaries:*** *Extension professionals, stakeholders (local, state, tribal, leadership), citizens (local, state, tribal)* *Discovery, Engagement* *Change in knowledge, Change in Intention, Change in Behavior*	
40	**MSUE Helps a Local Community Turn a Policy Change with Negative Ramifications for the Community into A Positive Community-Led Leadership Opportunity**	**Issue:** In 2017, legislative action directed the closure of the Boulder Montana Developmental Center (MDC), resulting in the loss of the largest community employer. **What has been done:** MSUE helped the community establish working groups to look at facility re-utilization options and coordinate with potential end users. Progress is being made with establishing a veteran pain management center, veteran support center, and commercial kitchen re-utilization. There are ongoing discussions about using the facility as a central training center for workforce development, central logistical distribution facility and medical component manufacturing. A site master plan and infrastructure analysis are in progress to help with future re-utilization decision making. A community $500,000 legislative appropriation helped mitigate the economic impacts from the closure of the MDC. **Results:** MSUE provided assistance and leadership with the implementation of the following:	Community Development (8)

		• a Downtown Master Plan, updated Growth Policy. • River Trails Master Plan with trail design. • Recreation Park Master Plan. • Establishing a $100,000 business Revolving Loan Fund (RLF). • Accomplishing downtown business building façade improvements. • Development of a Boulder brand and logo. • Erecting gateway signs. • Development of a Boulder website. • Constructing outdoor restrooms supporting increased park activities. • Installation of fiber optic high-speed internet lines. ***Likely beneficiaries:*** *Stakeholders (local leaders), citizens (local)* *Engagement* *Change in knowledge, Change in Intention, Change in Behavior, Change in Condition*	
41	**COVID-19**	In the spring of 2020 MSU as a whole changed instantaneously and foundationally. Students leaving for spring break were told not to return, all instruction became virtual, and shelter-in-place was ordered by the Governor. These broader state and university level changes impacted the COA, MAES, and MSUE. The COA leadership faced broader challenges in adapting the discovery, engagement, and learned components of a land grant institution. Some researchers indicated that their research was somehow hindered by COVID-19; the vast majority have continued their research successfully. Ongoing research projects were deemed essential by the university, which allowed travel and data collection to continue with rigorous safety protocols for those involved.	All

		MSU Extension developed a visioning document in April 2020, outlining how we address the needs of the people and places of Montana during COVID-19 and beyond. Key areas that surfaced include: • Community Vitality, Resiliency, and Leadership Development • Food Production, Safety, and Security • Economic Development and Personal Financial Security • Well-Being and Mental Health MSUE's efforts largely shifted to virtual education modalities. MSUE leadership adapted their engagement efforts across the counties and reservations within Montana. In-person meetings were not permissible in Montana's Phase 1 guidelines. During Phase 2, MSUE was able to find ways to introduce in-person events and interactions. While some county fairs were cancelled, the 4-H components (the celebration of a year's work on the part of the 4-H member) were allowed to continue with limited attendance and appropriate health precautions. The societal level upheaval opened opportunities and willingness from MSUE professionals and clientele that may not have existed otherwise. These shifts in modality will forever increase MSUE's opportunities to reach clientele more effectively in the future. Several responses to COVID-19 are highlighted in this report. While everything accomplished during the pandemic was impacted by it; COA, MAES, and MSUE have met the challenges with great success. The strengths of MSU, as a land grant institution, are the connection, trust, and contributions that occur in partnerships with people and organizations of Montana. Because of the strong long-term engagement and relevant research foundations of the COA, MAES, and MSUE, the abrupt adoption of new modalities was quite successful. The challenges faced in 2020 have made us stronger and will have lasting positive effects as we pursue our missions.	