

2014 Montana State University Research Plan of Work

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I. Plan Overview

1. Brief Summary about Plan Of Work

The Montana Agricultural Experiment Station (MAES) and the Montana State University College of Agriculture (COA) remain highly engaged with the agricultural and natural resource communities in many innovative ways. Investigators explore new and enhanced varieties of spring and winter wheat, delve into pest management and continue with leading research in animal health management, food safety, and food security. Researchers publish their findings in traditional formats and take advantage of breakthroughs in technology and the internet making them a key component in the advancement of agriculture techniques and productivity throughout the world.

Montana is a unique state boasting its "big sky" and "wide open spaces" both of which are indicative of the value Montanan's place on agriculture. Montana is a rural state with 989,000 people inhabiting 93 million acres which equates to fewer than seven people per square mile. The State's commitment to agriculture is clear with approximately 29,000 farms and ranches comprising more than 66 percent of Montana lands. Montana prides itself on its agricultural roots and its commitment to leading researchers in the agricultural community. In 1893 the Agricultural College of the State of Montana boasted eight students all of which were male. Now in 2013, the Montana State University College of Agriculture enrollment exceeds 1,000 students and half are women. The College also experienced its sixth consecutive year of increased enrollment with student numbers not seen since the early 1980s.

Agriculture experts at MSU have the globe as their classroom through technology and direct participation in diverse overseas experiences. Given the opportunity to extend their learning outside the classroom, students and faculty teach and learn in labs, greenhouses, farms, and ranches in Montana and around the world. Through collaborative research experiences and cooperation with rural, urban, and scientific communities, investigators are achieving significant impacts and outcomes.

Montana ranks 2nd in the U.S. in acres devoted to agricultural enterprises with annual crop and livestock cash receipts exceeding \$3 billion. Although Montana experienced droughts throughout the southern part of the state and struggled through a brutal fire season, the overall agricultural revenue reflected a 14 percent increase from 2010. According to the "2012 Montana Agricultural Statistics," the 2011 value of crop production increased to \$2.1 billion (19 percent above 2010). The value of livestock increased to \$1.4 billion, up \$156 million from 2010. Net government payments decreased by nine percent in 2011 to \$299 million.

Livestock products represented 40 percent of the cash receipts in 2011 with the majority being cattle and calves. Montana is among the top ten producers of beef cows and sheep in the nation and excels in honey and wool production. The sheep and lamb inventory was 235,000 head in January, up four percent from 2012, and Montana wool growers produced nearly two million pounds of wool during 2012, a four percent increase.

Producers saw an increase in the production of corn and sugar beets with production up 17 percent from 2011. Dry edible pea production, and canola were up as well, but hay production fell by 26 percent this year. In 2011 the state ranked 1st in the production of lentils and dry edible peas; 2nd in spring wheat, barley, Austrian winter peas and flaxseed; 3rd in the production of winter wheat, durum wheat, alfalfa hay,

safflower and canola; 4th in garbanzo beans and honey; 5th in all hay, 6th in the production of sugar beets; and in the top 10 for pinto beans.

Montana plays a key geographical role as the headwaters for the Missouri, Yellowstone, and Columbia Rivers. While Montana remains committed to agriculture it is also keenly tied to tourism and the recreational activities centered on the waterways. Researchers in Montana work to balance the needs of agriculture and value-added activities with conservation, recreation and environmental issues, so there will be enough water and other resources for multiple users. The State also plays host to two national parks which provide excellent research opportunities in the areas of climate change and food security.

Montana is home to seven American Indian reservations and twelve tribal nations. Nine percent of Montana's land base is "Indian Country," and the Native Americans represent the largest group of potentially underserved citizens in Montana comprising 6.2 percent of the population. MSU works with tribal councils and colleges across the Rocky Mountain region, and educators provide a variety of academic programs and opportunities on MSU campuses and within tribal communities. Cooperative efforts with MAES provide resources and training in: livestock management, certification, childhood obesity, nutritional recommendations, pasture restoration, environmental stewardship, sustainable agricultural practices, resource and risk management, and pesticide certification. American Indian students enrolled in the College of Agriculture comprise about five percent of the undergraduate populace, representing all seven reservations.

Researchers at Montana State University COA continue learning as they focus on diversity and efficiency in agricultural operations. MSU is committed to leading the way toward being better stewards of our natural resources and even more effective in developing intellectual and human capital across generations.

Priorities: The Montana agricultural community works together establishing the priorities for the College of Agriculture and the Montana Agricultural Experiment Station. Investigators and stakeholders facilitate focus groups and community meetings throughout the State ensuring the research priorities are current and valid for the target population. Following is a list of priorities:

- Add value to Montana's high quality crop and livestock systems
- Create new business opportunities for rural communities
- Develop effective livestock disease control methods
- Develop higher yielding and higher quality cultivars
- Expand research on agricultural and natural resource interactions
- Explore alternative and new crops
- Improve beef production practices and evaluate genetics to improve herds

Several priorities integrate as investigators in various departments collaborate and share results to ensure Montana remains on the cusp of the latest agriculture research.

Input Section: The MAES solicits stakeholder input in the strategic planning process and reaffirms the input as investigators fund, develop, implement, and revise the different research programs. The COA and MAES have 24 advisory committees and boards with more than 250 members. These include: the Animal and Range Science Advisory Committee, Center for Invasive Species Management Board, Center for Invasive Plant Management Science Advisory Council, Central Agricultural Research Center Advisory Committee, Assistant Dean's Student Advisory Council, Eastern Agricultural Research Center Advisory Committee (MonDak Region), Equine Advisory Committee, Foundation Seed Advisory Committee, MAES State Advisory Council, Beef Advisory Committee, Montana Farmers Union, Montana Pulse Growers Association, Montana Seed Growers Association Board, Montana Seed Lab Advisory Committee, Montana Wool Growers Advisory Committee, Northern Agricultural Research Center Advisory Committee, Northwestern Agricultural Research Center Advisory Committee, Organic Certification Association of

Montana, Potato Certification Board, Southern Agricultural Research Center Advisory Committee, Thermal Biology Institute Scientific Advisory Board, Variety Release and Recommendation Committee, Western Agricultural Research Center, and Western Triangle Advisory Committee. Members of these committees represent agricultural educators, agricultural organizations, communities, conservation groups, county extension agents, farmers and ranchers, financial organizations, private citizens, reservation groups, scientists, small businesses, and tribal councils. The COA and its MAES faculty respond to input from these stakeholders and state/national/international trends by continually developing new programs and evolving existing ones. Faculty members also serve on local and state committees.

Funding: Several sources fund MAES faculty research. They include: BIA, BLM, Canadian provinces, conservation and wildlife groups, Montana crop and animal agricultural groups, Montana Department of Agriculture, Montana Department of Environmental Quality, Montana Department of Natural Resources and Conservation, Montana Department of Transportation, Montana Fertilizer Advisory Committee, Montana Noxious Weed Trust Fund, Montana Wheat and Barley Committee, NASA, NIH, NRCS, NSF, other states, grants, overhead investments from sponsored programs, private donations, private industry, the State of Montana, USDA, USEPA, and USFS.

Outcomes and Impacts: MAES and the COA conduct research (integrated with teaching) to enhance economically viable and sustainable agricultural systems relevant to agriculture and producers in Montana with globally transferable solutions. The research focuses on issues and concerns relevant to fields traditionally outside agricultural parameters, but which involve similar advanced knowledge acquisition such as cancer research and energy development. They focus on interdisciplinary studies with far reaching impacts in science, technology, energy consumption, food security, safety, and hunger. Investigators in Montana are keenly aware of the environment and the implications of climate change.

Superior instructional programs emphasize student research skills and training in fields critical to the nation's agricultural and natural resources infrastructure so students will be marketable in traditional and emerging job markets. Outreach programs link researchers with educators, stakeholders, producers, and consumers through face-to-face communication, print media, and electronic methods. Information technology specialists continue enhancing electronic workflow for the research centers throughout Montana and increasing video conferencing capabilities.

The agricultural research centers scattered throughout Montana host annual field days in cooperation with USDA-ARS (two Montana locations) and allied communities. At field days the staff shares key research programs with members of the agriculture community, stakeholders, producers and those pursuing careers in agriculture and/or research. Staff members facilitate discussion forums where attendees exchange valuable information and ideas. The field days (attended by agricultural clientele, elected officials, and the general public with participation by faculty, staff, and students) are valuable for sharing new and ongoing research efforts.

Maintaining profitable agricultural enterprises while sustaining ecological systems has become a difficult balancing act that often results in changes in agricultural practices and environmental policy. Montana agriculture scientists are vigilant about guarding limited resources, focusing on water issues, and developing crop and livestock systems that improve sustainability. Studies focus on how to produce the high yielding crops with minimal production costs and reduced environmental impact. Researchers in plant sciences continue to investigate crop rotation with winter and spring peas, canola, corn, lentils, mustard, sunflower, triticale, and chickpeas. Pulse crops represent important new sources of income for farmers and provide opportunities for increasing crop diversity.

Program Areas:

Program #1 Climate Change and Environment

Situation: Montana, known for its rugged beauty and wide open ranges, also frequently makes national news because of its harsh and sometimes unpredictable climate. The Continental Divide runs north to south through the State and the rugged mountains often impact weather patterns resulting in very different conditions between the eastern and western parts of Montana. The average frost free zones vary throughout the state from 30 days to 125 days based on location and altitude. This alone plays a key role in crop selection and production in Montana. Researchers are also concerned about areas where diminished water resources place constraints on crop growth, and the impact of rising timberlines on range and croplands.

Priorities: The agricultural community in Montana wants to add value to Montana's high quality crop and livestock systems as ongoing adaptations to climate change. Leaders in the agricultural community have prioritized research exploring new and alternative crop varieties and high yielding cultivars. Researchers are also studying how the climate is affecting native plants, insects, and wildlife, as well as carbon sequestration. Research priorities also include water resource management.

Input: Focus groups, multistate research committees and meetings of stakeholders identify climate change strategies in cooperation with investigators.

Research Activities: Knowing that changes in the climate will impact agriculture, researchers at MSU COA and MAES are exploring new varieties of crops and continue introducing new varieties of barley and wheat. Investigators expect barley, one of the most durable cereal crops, to perform exceedingly well in a drier, warmer climate. They are also exploring the vegetation and microbes growing in the thermal pools of the Yellowstone ecosystem. By studying the mechanisms of growth to native plants in geothermal-modified soils they gain a better understanding of limitations and opportunities increasing temperatures may present in agricultural production.

Scientists at MSU COA and MAES are participating in a collaborative research project regarding carbon dioxide. Investigators are looking for the most effective ways to remove CO₂ from the atmosphere, store it in plants, and then release the carbon into the soil where it enhances plant growth.

The changing climate has significantly impacted Montana insects which in turn impact the ecosystem. Researchers are studying the biology, distribution, and systematics of insects. In 2012, they prepared 26,000 specimens of wood boring insects and are studying them to determine their impact on agriculture in the State.

The Montana landscape is changing along with the climate, and Montana scientists are concerned about the loss of sagebrush habitat due to conifer encroachment. Researchers are collecting data from three different areas in southwest Montana to determine the relationship between conifer and sagebrush.

MAES and COA researchers understand the direct correlation between agriculture-biofuel production, carbon sequestration, and natural resource conservation, as well as traditional commodity production. By studying these relationships and educating others, Montana agricultural producers can react effectively and sustainably to the demands of climate change.

Another MSU project is developing data to produce scientific publications and information for the public that will help public decision-makers formulate policies regarding climate change and greenhouse gas mitigation. Scientists are studying the fate of organic contaminants in soils and the potential contamination of surface and ground waters.

Program #2 Food Safety

Situation: MAES and COA researchers are committed to helping reduce food-borne illnesses and

assisting producers in providing a safer food supply. Consumers are demanding healthier, safer food free of harmful chemicals and pesticides, and the global market is driving industry changes with constraints on grain and animal products.

Animal health is economically essential to livestock producers who work diligently producing high quality, high profit stock. Promoting and maintaining animal health has led to advances in genetics and reproductive science and improved animal performance. Montana prides itself on being home to some of the greatest cattle and sheep operations in the United States, and also as a State with more wildlife than people. This brings about unique research opportunities as scientists balance health concerns of livestock, wildlife, and consumers.

Investigators at Montana State University COA are studying animal health and its impact on food safety through numerous studies exploring all aspects of livestock management from genetics research projects, disease identification and prevention, to animal breeding practices, reproductive sciences, and nutrition.

Studying infectious diseases is important to Montana researchers because of both the economic losses for producers and food safety concerns. Immunology and Infectious Diseases (ImID) focuses a great deal of research on animal health, and particularly infectious cattle diseases. ImID and the Animal and Range Sciences department have several joint research projects developing and testing new drugs, vaccines, and diagnostic tools for fighting infectious diseases of livestock, humans, and wildlife, as well as zoonotic diseases that can be transmitted to humans.

Priorities of Research for Food Safety

- Further knowledge and management of insects affecting animals and humans
- Develop effective livestock disease control methods
- Identify and mitigate the transmission of diseases between livestock and wildlife
- Increase wool and lamb competitiveness
- Implement targeted grazing strategies as weed control
- Nutritional impact of grazing on sheep and cattle
- Improve traceability of livestock

Input: Stakeholders provided input for the strategic planning process, and offer valuable input. Stakeholders include advisory committees for the Department of Animal and Range Sciences, Northern Agricultural Research Center, the Montana Beef Council, Montana Wool Growers, Montana Stockgrowers, USDA-ARS, and other regional research programs.

Research Activities: Scientists with Immunology and Infectious Disease (ImID) utilize molecular approaches to address basic and applied problems in infectious disease research. Disease management and research programs that increase the quality of meat, milk, and fiber products remain high research priorities. According to a leading scientist with ImID at MSU, digestive and respiratory diseases still account for more than 50 percent of the non-predator deaths in calves in Montana and scientist at MSU are working diligently to discover vaccines and treatment to minimize these losses. MSU studies help ensure Montana producers raise safe beef while improving quality. Research and educational programs address the animal health, biosecurity, and production efficiencies that concern producers and consumers.

Researchers are investigating diseases and animal productivity in cattle, sheep, and bison. MSU animal health projects are long-term with minimal yearly changes, but the quality research allows agriculture to remain the top Montana industry, and the advances in cattle and sheep management translates into an economic benefit to all Montana livestock producers. The research they do combating diseases is invaluable to Montana and the region. Viral pneumonias cause substantial morbidity and mortality in the cattle industry creating a need to develop effective vaccines. Investigating the mechanisms

by which calves resist lung infections is helping scientists better understand why calves become susceptible to infection.

Investigators are exploring novel approaches to both the compounds and the delivery methods. Researchers want to develop products and procedures that are safe, simple, and low cost, but will still stimulate immunity. Amphotericin B (AMB) is currently used to fight fungal infections in humans, and COA/MAES researchers are testing AMB in calves and dairy cows using different delivery methods like strips that dissolve on the tongue.

Rotavirus is the most important viral agent of neonatal diarrhea and generally affects calves less than six weeks of age. Researchers are studying the molecular interactions between enteric viruses and host cells to better understand rotaviruses. The results are important, because to enhance an effective defense response to viral infection, scientists must understand the molecular details of the pathways. The research in this field is important as it has the potential to develop attenuated vaccines consisting of viruses with weakened evasion strategies, or to target viral protein antagonists for antiviral drug development.

Bovine mastitis is the dairy industry's most costly disease. *Staphylococcus aureus* (*S. aureus*) is one of the most common causes of mastitis in cows, and current treatments are primarily dependent on ineffective antibiotics. A MSU research team is investigating the incidence and characteristics of *S. aureus* in Montana's dairy herds and studying the antimicrobial potential of a chemokine (a signaling protein) found in bovine milk. Recently, COA/MAES scientists isolated a chemokine CCL28 that appears to have an important role in mammary immunity.

At several of the research centers, investigators are developing new reproductive, genetic, and nutrient management strategies for rangeland-based animal agriculture. Research in targeted mutagenesis of cells in cattle will make milk and beef production more efficient, increase the value of cattle-based commodities, and produce herds with improved disease resistance and increased production capabilities.

Sheep production is a valuable component of Montana agriculture and investigators are starting several new projects aimed at increasing the health, productivity, and profitability of the sheep industry. Working closely with the Montana Wool Growers Association, a MSU researcher launched an investigation aimed at protecting sheep from the mosquito borne illness called Cache Valley Virus and also Bluetongue which is becoming a growing problem for sheep producers. Scientists are also continuing to look at the residual feed impact on market and wool lambs. Neonatal lamb mortality is a major source of lost income to the U.S. sheep industry. COA/MAES research has focused on nutritional strategies during late gestation that may impact fetal survival and immune functions. Researchers are also working with area ranchers to better track the genetics of their herds.

Food safety and security have become important concerns for the beef industry at all production levels. Domestic and international consumers are demanding more information about the source of the meat products they purchase, including the age, health, nutrition, and handling management of the animal. MSU studies help ensure that Montana producers raise safe beef while improving the quality of the beef. COA/MAES investigators are ensuring consumers are aware of the quality and health of their products through advancements in the traceability of livestock.

MAES researchers and university professors in the College offer educational programs on beef quality assurance practices, voluntary beef cattle marketing options, and ranch management issues throughout the State via meetings and interactive technologies. They have developed programs that focus on management, nutrition, and health maintenance and provide cow-calf producers in Montana with the tools to produce higher quality beef that is healthy and safe for consumption.

A lead researcher with the COA Land Resources and Environmental Sciences Department is focusing a research program on comparative biological and agricultural risk assessment from biotechnology crops, pesticides, and invasive species. Risk assessment activities in 2012 emphasized pesticides (mosquito insecticides), biotechnology crops, mortality risk in insects, and invasive species and biological control (weeds and biological control agents). Research included human health risk assessments for West Nile virus compared to mosquito insecticides, comparative risk assessments of pest management technologies, and invasive weed and biological control environmental risk assessments.

Program #3 Global Food Security and Hunger: Integrated Pest Management

Situation: The MSU COA and MAES looks outward with a keen awareness on global food security and a desire to stimulate research in the agricultural industry through dynamic and comprehensive rural leadership programs, technological advancements, and proven scientific and educational practices. The College understands the need for research, education and extension to boost U.S. agricultural production and improve the global capacity to meet the growing food demand. MSU approaches the global food security and hunger program in two areas. The first is integrated pest management, and the second key program area in global food security focuses on plant breeding, genetics, and genomics.

An increase in public concern about food safety, quality, cost, biodiversity, and the sustainability of natural resources such as soil, air, and water quality is pushing scientists to rely less on pesticides and look for more environmentally friendly options. Researchers explored new and improved methods to identify and control insects, weeds, and diseases challenging Montana farmers. MSU investigators studied biological controls as low impact pest control options to promote sustainable practices. Producers and researchers are evaluating these new integrated pest management (IPM) methodologies so they can maintain a competitive position in U.S. and world markets while helping alleviate global hunger.

Montana is a key provider of grains in the United States and also on the global market. Crop success in Montana is important to the global food market. In Montana and throughout the U.S., maintaining profitable agricultural enterprises while sustaining ecological systems has become a difficult balancing act that often results in changes in agricultural practices and environmental policies. In a semi-arid state most crops are dependent upon irrigation from surface water and groundwater. Stream flow, groundwater, surface water, fisheries, and wildlife are heavily dependent on winter snowpack for their water supplies. Irrigated agriculture is the largest user of freshwater in Montana with 1.7 million acres under irrigation using approximately 9 million acre-feet of water annually. Education and research activities have precipitated a general trend toward more efficient irrigation systems and more drought tolerant crops.

Priorities: IPM programs optimize grower profitability and natural resource sustainability through the development, selection, and implementation of economically sound and environmentally acceptable pest management strategies. MSU researchers explored less chemically dependent systems and are addressing the economic feasibility and environmental impact of alternative controls and growth of organic systems. The COA and MAES taught growers more about crop rotation systems, crop production methods, and water management issues that help produce high quality crops and mitigate pest problems. Researchers are working with the Forest Service studying the impact of ecological and climate changes to pest management. By understanding ecological relationships researchers will implement more biological controls and science-based systems for pest management.

Input: Summaries of survey information from the Montana weed coordinators identified research needs in the management of invasive plants on private, public, and agency lands. This led to new state funding, research, and educational initiatives aligned with the multi-agency and citizen-supported Montana Weed Management Plan. Funding sources include: Montana crop and animal agricultural groups, Montana Ag Business Association, Montana Department of Agriculture, Montana Fertilizer Advisory Committee,

Montana Noxious Weed Trust Fund, Montana Wheat and Barley Committee, other states, private donations, private industry, Sustainable Agriculture Research and Education (SARE) program, and USDA. Researchers collected stakeholder input in county and reservation sponsored meetings, listening sessions during pesticide applicator education programs, and during a Farm Bill Forum. The development of more environmentally-friendly chemical and non-chemical alternatives requires on-going interaction with chemical and biological pest control product manufacturers, state and federal agencies, and researchers in other states.

Research Activities: Research focused on how to control troublesome weeds and insects more effectively. Montana sheep researchers studied the impact of targeted grazing on noxious weeds throughout the region. Targeted sheep grazing is an economical and ecologically sustainable tool to manage lands with large infestations of invasive plants such as Dalmatian Toadflax. Investigators with COA and MAES worked with 1,000 private landowners, county weed supervisors, and public agencies to develop new sheep grazing protocols and projects.

While sheep grazing is effective, invasive plant species remain a serious problem on Montana's range and forested lands. Noxious weeds impact productivity and compromise the ecological integrity of all Montana's land. Researchers are investigating the use of biological control for the management of noxious weeds and especially the use of insects. Researchers are introducing natural enemies into the environment in an attempt to control the weeds. The USDA Animal Plant Health Inspection Service approved a specific gall wasp and a gall midge for field release, and investigators released gall midges in Montana and Wyoming. They are currently analyzing the data and rearing more insects for further releases.

Investigators are also studying insects helpful to agriculture as well as the community's greatest pests. They are enhancing their understanding of the diversity, distribution and activities of pollinators, and also making significant advancements in handling troublesome moths and wheat stem sawflies.

Program #4 Global Food Security and Hunger: Animal Health, Production, and Products

Situation: Montana ranchers contributed 5 percent of the U.S. total beef cow production in 2012 and 6 percent of the U.S. lamb production. As the market becomes more global it is important that agricultural production meets the growing food demand. Research programs at MSU COA and MAES focus on reproductive performance in animals, nutrition, genetic improvements for herds, and developing better animal management systems.

Priorities:

- Enhance reproductive performance of animals
- Evaluate and design better feed systems using the right nutrients
- Evaluate genetics to improve herds
- Study carcass composition

Input: Foreign trade teams, international trade missions, faculty, staff, and students establish funding recommendations and priorities. Stakeholders provided input for the strategic planning process, and offer valuable input. Stakeholders include advisory committees for the Department of Animal and Range Sciences, Northern Agricultural Research Center, the Montana Beef Council, Montana Wool Growers, Montana Stockgrowers, USDA-ARS, and other regional research programs.

Research Activities: Focusing on sustainable agriculture practices MAES and COA researchers in the sheep industry are exploring an integrated system of plant and animal production practices that will have a long-term impact on human food and fiber needs.

Researchers at MSU designed a project that will emphasize a combined animal and plant approach. The study will look at the following: 1) Reduce tillage intensity in organic crop systems using sheep grazing to terminate cover crops and control weeds; 2) Document best management practices that reduce the use of anthelmintic and/or promote strategic, effective use of anthelmintics, and 3) Develop low cost alternatives to confinement lamb finishing, as well as systems that provide year-around quality lamb that profit from integrated production systems.

Failure of cows to rebreed after calving significantly decreases reproductive efficiency of beef cattle production. Extended postpartum anestrus is the single most important reason that cows fail to rebreed. This problem is exacerbated by primiparous cows, because they require significantly more time after calving to resume estrus/ovulatory activity than multiparous cows. These factors result in a substantial economic loss to the beef industry in Montana and the U.S. The biostimulatory effect of bulls can accelerate the resumption of ovulatory activity in anovular, postpartum, suckled cows; increasing the likelihood of cows that produce one calf per year and, in turn, increase overall reproductive efficiency and profitability of beef cattle production. Researchers at MSU are trying to determine the physiological mechanism(s) and pheromonal pathways and how they impact fertility in heifers and cows. Scientists are conducting similar biostimulatory research with sheep.

Investigators are also studying the relationship of growth path to carcass composition and meat quality and how to increase the value of beef cattle within Montana. Researchers are looking at the new crops developed in Montana and evaluating them as a potential food source for livestock.

While producers work diligently to grow quality crops in Montana weeds grow easily and in great abundance. In Montana, about eight million acres are seriously infested with noxious weeds. Previous research at MSU indicates that sheep and/or goat grazing offers an additional tool in the fight against noxious weeds in an integrated weed management program. Two researchers are heading a project to develop and implement new management strategies for livestock and land managers for the use of small-ruminants in controlling large infestations of non-native invasive plants while maintaining a production system which is profitable. Targeted grazing is a natural approach to vegetation management and landscape enhancement. Besides providing an ecologically sound and economically feasible tool to manage one of the west's most serious environmental threats, this initiative develops and implements new approaches that improve Montana lamb and wool producers' competitiveness in a world economy. Incorporating targeted grazing in integrated natural resource and weed management programs will create additional income opportunities for rural Montana families. This project falls under both plant management systems and animal health.

Program #5 Global Food Security and Hunger: Plant Improvement, Genomics, and Products

Situation: As the third leading producer of wheat products in the United States, Montana, through MAES and COA investigators continued researching new and better varieties of wheat cultivars and made significant advances in both the spring and winter wheat breeding programs. The value of Montana's 2012 crops was \$2.1 billion, according to national agricultural statistics. Progress has been made in winter wheat cultivar development. Yields have improved an average of 0.8 and 1.2 bu/acre/cycle over ten breeding cycles (2002-2012) in MAES hollow and solid stem lines, respectively. The spring wheat breeding program contains materials from initial crosses to lines being evaluated for potential release. Solid stems, high yields, and good end-use quality are primary selection targets. A goal over the next few years is to make crosses with diverse lines from other programs to increase genetic diversity. Researchers will continue developing new cultivars of small grains that are marketed globally.

Priorities: Researchers are investigating high yielding crop varieties resistant to insects and diseases and that will perform well in the Northwest Region. The agricultural community and allied industries depend on new cultivars to remain competitive in the world marketplace. Primary breeding

objectives include increasing yield potential, improving winter hardiness, enhancing wheat stem sawfly resistance, and improving dual-purpose end-use quality grains. MSU's intensive genomic research will help Montana producers stay competitive and provide improved cultivars adapted to Montana's climatic conditions and cropping systems. An increased understanding of the molecular biology and biochemistry of cereal grains will lead to the development of products more suited to the requirements of a competitive world market and help alleviate world hunger. Continued productivity of the breeding program will improve the understanding of the genetics from key traits and allow the development of new selection tools. The broader impacts of the work are a larger and higher quality food supply for the world, an improved ability of Montana farmers to compete in a global marketplace, and a strengthening of export markets for U.S. wheat.

Input: Foreign trade teams, international trade missions, faculty, staff, and students establish funding recommendations and priorities. Farmers cooperate by providing dryland and irrigated fields for cultivar trials and by providing associated inputs. The Montana Wheat and Barley Committee competitively awards research proposals. The COA and MAES routinely apply for PVP Title V status on all released wheat and barley cultivars, which then increases revenues for research. Surveys at farm conferences in Montana highlight strong producer interest in increasing crop diversity. Information and financial assistance come from alternative energy groups, equipment companies, crop protection companies, Fertilizer Advisory Committee, Montana Wheat and Barley Committee, Organic Certification Association of Montana, and state agricultural advisory committees. MAES and the COA will continue to host meetings, interviews, and focus groups to gather information from stakeholders, they will also use computer modeling and surveys to gather and compile data. The agricultural industry, faculty, and other regional institutions have created partnerships among producers that provide outreach activities related to bio-based products. Investigators use input from focus groups and stakeholders to identify strategies for marketing safe agricultural commodities and consumer products.

Research Activities: MSU seeks to maintain its role as a leading university in small grains genetics research. The agricultural community and allied industries depend on new cultivars to remain competitive in a global marketplace. Primary breeding objectives included increasing yield potential, improving winter hardiness, improving wheat resistance to sawfly, and enhancing dual-purpose end-use quality grains.

Investigators are researching several types of winter wheat. In 2012, Montana farmers planted more than 500,000 acres of "Yellowstone" followed closely by "Genou." Both varieties have been rapidly accepted by Montana producers and represent significant yield advancements and increased grain production. "Yellowstone" is the highest yielding winter wheat line ever developed at MSU. "Decade" adds increased winter hardiness and reduced plant height at a similar yield level. According to the lead investigator "Judee" and "Bearpaw," both solid-stem semi-dwarf cultivars are expected to replace "Genou," whose popularity has declined since the 2011 stem rust epidemic. Excellent progress in selection of lines with stripe rust resistance was made in 2011 and 2012. Several promising experimental lines are emerging from the testing program and are being increased and considered for variety release.

Montana's spring wheat acreage during the past five years has ranged from 44 to 55 percent of the total wheat acreage planted. In 2012, Montana producers planted 2.9 million acres of spring wheat, up from 2.5 million in 2011. The state remains the second largest spring wheat producer in the country, according to the USDA NASS, Montana Field Office. "Vida," "Choteau," "Reeder," and "Corbin" accounted for more than 55 percent of all Montana's 2012 spring wheat acreage and two of them were developed by the MAES. Hard red spring wheat is grown in all areas of the State, with more than 97 percent of the acreage on dryland.

Researchers continued to advance malting barley lines and improved feed, hay, and food barley varieties. Researchers have almost completed their food barley breeding effort and plan to release new varieties for the 2014 planting season. In 2006, breeders expanded the germplasm base to include several

potential sources of improved drought stress tolerance from Asia, and one of these lines (MT 103022) performed well in its first year of testing in the 2012 Montana Intrastate Barley Trial. In the coming months, breeders will propose releasing several new hulless varieties, some to replace "Prowashonupana," and other low fiber hulless barely lines to support the swine and poultry industries. Several new hay barley lines have one more year of forage yield trials prior to release and the breeding team has new low grain protein malt barley lines entering the pilot scale trials this spring.

To decrease Montana's primary dependence on small grains and forage crops, researchers are also exploring the feasibility of growing a variety of crops including pulse crops (peas, lentils, chickpeas, and soybeans), herbs, mustard, safflower, sunflower, canola, turf grass, and specialty grains. Increasing crop diversity will improve the economic well-being of dryland agricultural producers in Montana and the Northern Plains. MSU research provides technology that improves plant and animal production systems while adding value and enhancing food security for stakeholders. Initiatives will provide new insights into food safety and risk assessment.

Researchers at the Experiment Station are making significant progress in four areas: peas and lentils, hooded barley, spineless safflower, and winter triticale. Researchers also are successfully planted and harvested Austrian winter, green, and yellow peas throughout Montana. Scientists selected improved hooded hull-less barley lines for forage and grain production with higher levels of beta-glucan, a soluble fiber. Researchers will continue to develop shorter season safflower as another rotational crop producers can market as bird seed, cattle forage, and upland game bird habitat. The triticale, a cross between rye and wheat, offers producers an alternative forage crop that also has good potential for food as it is often found in seven grain breads and grows well in Central Montana. Dry pea crops are proving well-suited to the agricultural practices common in Montana and neighboring states. It provides an economically viable alternative to wheat, barley and canola, and helps condition the soil for these other crops through its ability to add nitrogen, its low water use, and its impact on pests, weeds, and diseases. The current project will take advantage of the recent developments understanding the legume genome to develop new pea varieties specifically adapted to conditions in Montana and the Northern Great Plains.

Sustainable Energy

Situation: Research in sustainable energy is now conducted through non-MAES entities. MAES energy research will be incorporated into Climate Change and Environment, and Global Food Security: Plant Improvements, Genomics, and Products. We will not maintain sustainable energy as a planned program.

Estimated Number of Professional FTEs/SYs total in the State.

Year	Extension		Research	
	1862	1890	1862	1890
2014	0.0	0.0	311.5	0.0
2015	0.0	0.0	311.5	0.0
2016	0.0	0.0	311.5	0.0
2017	0.0	0.0	311.5	0.0
2018	0.0	0.0	0.0	0.0

II. Merit Review Process

1. The Merit Review Process that will be Employed during the 5-Year POW Cycle

- Internal University Panel
- External Non-University Panel
- Other (Dept. Head External to PI's Dept.)

2. Brief Explanation

Department heads with the MAES and COA review Hatch Projects at the department level. A committee of peers then reviews the project and passes it to the director for final approval. The MAES director's office ensures this process is done as efficiently as possible. The peer review committee, selected by the director after consultation with COA department heads, includes the principle investigator's (PI) department head, MAES administrator, one department peer reviewer and two additional faculty external to the PI's department. Researchers present seminars to the review committee and interested stakeholders, including faculty, staff, students, and constituents. The director requires researchers to propose new projects for a three year period, while researchers with favorably reviewed ongoing projects continue for five years. Because there are not any Montana Agricultural Experiment funds allocated outside of the COA, external expert reviews occur with Montana State University faculty external to the COA, as a requirement of the review process. Presenters announce all seminars ensuring broader attendance and input potential. Reviewers provide written recommendations on the following: relevance and importance of the project; relationship of the project to previous research; objectives; approach and methods; scientific and technical quality; resources; environmental, economic, and/or social impacts. The MAES administrator and department head share the responses with the PI. If the projects do not meet expectations the director will not approve them and will defer them until the researcher meets the key elements satisfactorily. Ultimately, the office staff submits the director-approved projects to USDA-NIFA for final approval.

Local advisory committees to the research centers provide annual and longer-term guidance.

III. Evaluation of Multis & Joint Activities

1. How will the planned programs address the critical issues of strategic importance, including those identified by the stakeholders?

Planned research programs adhere to regional and Montana protocols and priorities through continual review at regional and State levels. The Western Region of Experiment Station Directors reviews productivity through careful committee analysis of annual results tied back to the regional objectives. Direct ongoing participation of faculty, staff, and students on the projects in Montana feed into multi-state projects and selected objectives. In addition, on a biennial basis MAES is reviewed and funded by the State. In non-legislative years, the Legislative Fiscal Analysis Division reviews goals and performance measures for compliance.

2. How will the planned programs address the needs of under-served and under-represented populations of the State(s)?

Montana has a small population and an even smaller number of under-served and under-represented populations. Where applicable and where there is good opportunity for success, we are actively engaging in collaborative research and education that would address Native

American issues. We are working closely with Reservation County Agents to identify key problems that, if they align with our expertise and resources, will result in research that addresses key issues and problems. The MAES is also working with the USDA-ARS on collaborative projects at facilities and associated regions in Sidney and Miles City, Montana. In addition, Bozeman-based faculty members periodically teach at the 1994 Institutions.

3. How will the planned programs describe the expected outcomes and impacts?

To continue receiving State support that is five times the amount of federal support (Hatch, Multistate, and Animal Health), MSU COA and MAES research must demonstrate actual or potential economic impact to Montana's economy and solve local and state level problems. This could be measured as increased crop yields or through advances in crop or animal production efficiency. Deriving additional income from value-added products and new enterprises helps diversify risk and create additional opportunities for income. As a result of the new knowledge created through research activities, there may be policy changes that impact agency management decisions. Based on average planted acreage and prices, development of an improved winter wheat cultivar that produces an additional one bushel per acre either by enhanced yield or reduced yield loss to disease, insects, or environmental stresses adds \$4-\$5 million in revenue per year to Montana's economy. The alternative use of coal bed methane waters for irrigating salt and/or sodium tolerant crops can lead to the development of energy resources in an environmentally sound and economically feasible manner. This could lead to new policies on drilling for methane and the use of extracted waters. Many of the coal bed methane sites are located on reservations; working with tribal leaders helps identify their needs in those locations.

4. How will the planned programs result in improved program effectiveness and/or

The process of problem identification includes meeting with agricultural and natural resource organizations, securing funding for research operations, and reporting to state and federal officials. This process assists in modifications that lead to improved program effectiveness in delivering research results that, in many cases, enhance agricultural efficiency through new or alternative practices. Research programs take the inherent initial risk, and stakeholders ultimately weigh in on program effectiveness through adoption of new technologies and approaches that provide additional income, reduce risk, and sustain the enterprise. Montana stakeholders provide the impetus for continued and growing financial support through MAES programmatic emphases important to the State's number one industry, agriculture.

IV. Stakeholder Input

1. Actions taken to seek stakeholder input that encourages their participation

- Use of media to announce public meetings and listening sessions
- Targeted invitation to traditional stakeholder groups
- Targeted invitation to non-traditional stakeholder groups
- Targeted invitation to traditional stakeholder individuals
- Targeted invitation to non-traditional stakeholder individuals
- Other (Educational outreach programs)

Brief explanation.

The Montana Agricultural Experiment Station (MAES) and COA obtain stakeholder input on research priorities and programs. Stakeholder committees include the sustainable agriculture focus group, MAES State Advisory Council, Ag Coalition and other state and local groups. MAES scientists routinely participate with this group and NRCS to provide training and expertise in the

geospatial sciences. The Ag Coalition consists of representation from the Agricultural Business Association, Farm Bureau Federation, Montana Stockgrowers, Montana Farmers Union, Montana Water Users, Montana Wool Growers, Seed Growers, and the Seed Trade. It meets periodically with the dean and director to review program priorities, new initiatives, fundraising efforts, and legislative activities. The College advertises the meetings via news releases, newsletters, individual letters, and announcements at group meetings. Extension agents use county profile information to ensure those invited to the sessions reflect the diversity of the area. The MAES responds to stakeholder inputs by considering their proposals at research planning meetings with scientists, advisory groups, and administrators. Administrators solicit stakeholder input at the strategic planning process and as programs are developed, implemented, and sometimes redesigned.

2(A). A brief statement of the process that will be used by the recipient institution to identify individuals and groups stakeholders and to collect input from them

1. Method to identify individuals and groups

- Use Advisory Committees
- Open Listening Sessions
- Other (Volunteers, membership on ag. assoc. boards)

Brief explanation.

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

2(B). A brief statement of the process that will be used by the recipient institution to identify individuals and groups who are stakeholders and to collect input from them

1. Methods for collecting Stakeholder Input

- Meeting with traditional Stakeholder groups
- Meeting with traditional Stakeholder individuals
- Meeting with the general public (open meeting advertised to all)
- Survey specifically with non-traditional groups
- Meeting specifically with non-traditional individuals

Brief explanation.

Through direct participation with agricultural stakeholder groups, broad participation in committees, and directed meetings, MAES listens to and considers defined problems or questions that the research programs can address. The Director targets selective meetings with non-traditional groups. Montana has an open meeting law. Therefore, all meetings are open to the public and the organizer must publish an agenda.

3. A statement of how the input will be considered

- In the Budget Process
- To Identify Emerging Issues
- Redirect Research Programs
- In the Staff Hiring Process
- To Set Priorities

Brief explanation.

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

Advancements in the Animal and Range Sciences Department provide an example of how stakeholder input resulted in specific actions. Stakeholder requests for a more comprehensive beef, cattle, and genomics program resulted in:

- A state-of-the-art Animal Bioscience Building built in 2010
- Three new full-time faculty positions in Animal and Range Sciences
- New equipment

The new equipment includes a:

- Ion Torrent Personal Genome Machine for profiling genetic information taken from livestock samples
- Illumina MiSeq which collects specific information from multiple DNA molecules helping scientists study microbial life in a sample
- Maxwell 16 (a machine which extracts nucleic acid and runs 16 DNA samples at a time)
- Polymerase chain reaction machine
- Refrigerated micro centrifuge
- Computer bio-analyzer which measures RNA and DNA samples
- Necropsy down-draft tables for laboratories complete with ceiling cameras

The Land Resources and Environmental Sciences department had a comprehensive external review and the College is actively working on the recommendations from the review with particular emphasis on reshaping our undergraduate curriculum to include core competencies, and exploring stakeholder interactions.

V. Planned Program Table of Content

S. No.	PROGRAM NAME
1	Climate Change and Environment
2	Food Safety
3	Global Food Security and Hunger -- Integrated Pest Management
4	Global Food Security and Hunger: Plant Improvements, Genomics, and Products
5	Global Food Security and Hunger: Animal Health, Production, and Products

V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

Climate Change and Environment

2. Brief summary about Planned Program

Researchers at MSU are exploring carbon sequestration in rangelands and croplands, the movement of energy and materials through agro ecosystems, and microbial ecosystems. The research is centered on developing new crops and cultivars suitable to a warmer and drier climate as well as exploring the ecological impact of climate change on natural wildlife habitats in Montana and grazing areas. Montana scientists have taken advantage of their close proximity to Yellowstone National Park to study flora growing in or near hot springs. Understanding the mechanisms of growth of these native plants in geothermally-modified soils will help researchers understand the limitations and opportunities that increasing temperatures may present to agricultural production.

As the climate changes, the need for drought resistant cultivars of Montana crops increases. Therefore, researchers continue discovering and evaluating new crops and cultivars of spring wheat, winter wheat and barley suitable for a warmer and drier climate. They are also studying how climate change impacts insects throughout the State.

Educational programs are being established as an introduction to the aspects of global climate change and its implications for agriculture. Agriculture has the potential to contribute to mitigation of climate change by sequestering carbon in soils. One MSU project is developing data to produce scientific publications and information for the general public that will improve the ability of public decision-makers to formulate policies regarding climate change and greenhouse gas mitigation. Additional projects are investigating the potential for soil carbon sequestration in rangelands and croplands.

Studies are in place to learn more about seasonal patterns and cumulative N₂O emissions from agricultural soils in the Northern Great Plains under different cropping systems, water regimes, crop residue levels, and nitrogen fertility rates.

As the demand for water increases and resources decline, researchers are designing forecast and water management models for watershed and runoff controls. COA scientists focused on three activities (1) the development and assessment of new hydrologic models for mountain headwater catchments; (2) developing methods for model calibration and Bayesian inference for hydrologic models; and (3) implementing methods for predictions and quantification of uncertainties in ungauged catchments.

MSU researchers will look at how climate change and human activities have altered fire activity in areas with different climates, especially in sensitive forests in the U.S., Australia, and New Zealand.

3. Program existence : Intermediate (One to five years)

4. Program duration : Long-Term (More than five years)

5. Expending formula funds or state-matching funds : Yes

6. Expending other than formula funds or state-matching funds : Yes

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
101	Appraisal of Soil Resources			7%	
102	Soil, Plant, Water, Nutrient Relationships			20%	
111	Conservation and Efficient Use of Water			10%	
112	Watershed Protection and Management			5%	
121	Management of Range Resources			10%	
122	Management and Control of Forest and Range Fires			5%	
132	Weather and Climate			2%	
133	Pollution Prevention and Mitigation			5%	
136	Conservation of Biological Diversity			10%	
201	Plant Genome, Genetics, and Genetic Mechanisms			12%	
216	Integrated Pest Management Systems			12%	
903	Communication, Education, and Information Delivery			2%	
	Total			100%	

V(C). Planned Program (Situation and Scope)

1. Situation and priorities

Situation: MSU College of Agriculture has expanded research in the planned program, climate change. The original studies focused on carbon dioxide in the hot springs of Yellowstone National Park (YNP) and carbon sequestration in rangelands and croplands. Now as researchers learn more about climate change they are concerned about the potential impact on forests and rangelands and the ecosystems. Experts warn a warmer climate will likely result in more disturbances such as wildfires, floods, droughts, insect infestations, and an increase in invasive plants. While agriculture is vulnerable to climate change as diminished water resources constrain crop growth, it also must be considered in context of rising timberlines, land use, and invasive species.

Priorities: The COA/MAES priorities are to investigate how climate change may impact crop production, water systems, and range and forestry management. The College is also exploring the impact a changing climate may have on native plants, insects and wildlife. Scientists are developing models and projects to ensure crop and livestock producers and land managers have timely and accurate information. Researchers must continue developing alternative crop varieties and high yielding cultivars that can grow in warmer and drier climates.

2. Scope of the Program

- In-State Extension
- In-State Research

V(D). Planned Program (Assumptions and Goals)

1. Assumptions made for the Program

- Corporate funding organizations, grain and livestock associations, companies, and other agencies will continue to provide input into priorities and activities
- Full-time staff and part-time assistants will be available to maintain appropriate progress
- Funding and technical support will be maintained from partnering institutions and cooperators
- Program development will proceed as planned without major interruptions

2. Ultimate goal(s) of this Program

- Develop drought tolerant crops suitable for growing in warmer and drier climates
- Develop carbon sequestration programs that utilize new technologies
- Identify plant mechanisms that allow plants to grow in geothermally-modified soils
- Determine impact of climate on integrate pest management programs

V(E). Planned Program (Inputs)

1. Estimated Number of professional FTE/SYs to be budgeted for this Program

Year	Extension		Research	
	1862	1890	1862	1890
2014	0.0	0.0	76.6	0.0
2015	0.0	0.0	76.6	0.0
2016	0.0	0.0	76.6	0.0
2017	0.0	0.0	76.6	0.0
2018	0.0	0.0	76.6	0.0

V(F). Planned Program (Activity)

1. Activity for the Program

- Develop new crops and cultivars suitable to a warmer and drier climate
- Explore the ecological impact of climate change on Montana wildlife habitats and grazing areas
- Study the impact of a changing climate on insects
- Develop and enhance pest management programs
- Continue investigating crops and management systems that rely on less water consumption
- Complete 10 year carbon sequestration research project

2. Type(s) of methods to be used to reach direct and indirect contacts

Extension

Direct Methods	Indirect Methods
<ul style="list-style-type: none"> ● Workshop ● Demonstrations 	<ul style="list-style-type: none"> ● Newsletters ● Web sites other than eXtension

3. Description of targeted audience

- Crop and livestock producers in Montana
- State agricultural advisory committees
- State of Montana, Montana Department of Agriculture, BLM, USFS, and other government entities
- Participants in extension and commodity group meetings, conferences, and field days

V(G). Planned Program (Outputs)

NIFA no longer requires you to report target numbers for standard output measures in the Plan of Work. However, all institutions will report actual numbers for standard output measures in the Annual Report of Accomplishments and Results. The standard outputs for which you must continue to collect data are:

- Number of contacts
 - Direct Adult Contacts
 - Indirect Adult Contacts
 - Direct Youth Contacts
 - Indirect Youth Contact
- Number of patents submitted
- Number of peer reviewed publications

Clicking this box affirms you will continue to collect data on these items and report the data in the Annual Report of Accomplishments and Results.

V(H). State Defined Outputs

1. Output Measure

- Number of research citations

Clicking this box affirms you will continue to collect data on these items and report the data in the Annual Report of Accomplishments and Results.

V(I). State Defined Outcome

O. No	Outcome Name
1	Number of new stress tolerant crop recommendations (or changes) for Montana
2	Number of new technologies explored

Outcome # 1

1. Outcome Target

Number of new stress tolerant crop recommendations (or changes) for Montana

2. Outcome Type : Change in Action Outcome Measure

3. Associated Knowledge Area(s)

- 132 - Weather and Climate
- 903 - Communication, Education, and Information Delivery

4. Associated Institute Type(s)

- 1862 Research

Outcome # 2

1. Outcome Target

Number of new technologies explored

2. Outcome Type : Change in Action Outcome Measure

3. Associated Knowledge Area(s)

- 132 - Weather and Climate
- 903 - Communication, Education, and Information Delivery

4. Associated Institute Type(s)

- 1862 Research

V(J). Planned Program (External Factors)

1. External Factors which may affect Outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Appropriations changes
- Public Policy changes
- Government Regulations

Description

- Inadequate funding and technical support from partnering institutions and cooperators
- Inadequate moisture (rainfall, irrigation, snowpack) for consistent crop production
- Lack of full-time staff and part time assistants
- Major interruptions in program development
- Reduced support from Montana crop and animal agricultural groups, conservation and wildlife groups, private industry, private donations, and other agencies

V(K). Planned Program - Planned Evaluation Studies

Description of Planned Evaluation Studies

Evaluation studies will be conducted annually through the issuance and collection of surveys, published peer reviewed materials, and secured peer reviewed grants. Long-term studies will be conducted throughout the State at various test sites, labs, and greenhouses.

V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

Food Safety

2. Brief summary about Planned Program

Producing high quality animals and obtaining the highest profit potential are essential for Montana. Promoting and maintaining animal health (cattle, sheep, horses, and wildlife) has led to advances in genetics and reproductive science and improved animal performance. By understanding immune systems and parasite development in livestock, and by developing novel genes and new biochemical routes of activity for drugs and vaccines, ranchers can better manage economically important diseases like coccidiosis, shipping fever, and brucellosis. Montana developed an integrated network to track calves from Montana ranches to feedlots and packing plants in other states. Tracking will provide both source and process verification for easy trace-back in case there is a disease outbreak.

Research Activities:

Cattle research focuses on disease control, reproductive enhancement, and animal productivity. Scientists will continue investigating vaccines for rotavirus, strangles, respiratory diseases, and mastitis in cattle. Researchers are using feed studies with barley, camelina meal, and supplements to evaluate varying rations for calves and cows, and to continue producing superior feeder stock to markets outside of Montana. Scientists are devising research to understand the cause and development of immunity to bovine shipping fever and to develop novel strategies for the prevention and control of this disease complex.

Researchers in the sheep industry are studying targeted grazing strategies to increase the competitiveness of Montana's lamb and wool in the world market. They are also studying the impact of sheep grazing in weed management programs. Scientists are initiating studies about Blue Tongue and Cache Valley Virus, which are both critical diseases for lamb and sheep populations.

The new innovative undergraduate major in Sustainable Food and Bioenergy Systems (SFBS) will be tracked under this planned program. The SFBS program adds new education and research opportunities to students and faculty through the interdisciplinary degree program which promotes sustainable production, distribution, and consumption of nutritious food and bioenergy by growing a new generation of leaders through collaborative learning and hands-on experience. SFBS students will explore various aspects of food and bioenergy systems as well as career opportunities in the sustainable food systems, agro-ecology, and sustainable crop and livestock production options. The SFBS program combines classroom learning, research opportunities, and meaningful field experiences to prepare students for careers that will impact the future of food and energy production.

3. Program existence : Intermediate (One to five years)

4. Program duration : Long-Term (More than five years)

5. Expending formula funds or state-matching funds : Yes

6. Expending other than formula funds or state-matching funds : Yes

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
121	Management of Range Resources			12%	
301	Reproductive Performance of Animals			5%	
302	Nutrient Utilization in Animals			11%	
303	Genetic Improvement of Animals			7%	
305	Animal Physiological Processes			4%	
306	Environmental Stress in Animals			2%	
307	Animal Management Systems			11%	
308	Improved Animal Products (Before Harvest)			12%	
311	Animal Diseases			21%	
315	Animal Welfare/Well-Being and Protection			7%	
503	Quality Maintenance in Storing and Marketing Food Products			5%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			1%	
902	Administration of Projects and Programs			1%	
903	Communication, Education, and Information Delivery			1%	
	Total			100%	

V(C). Planned Program (Situation and Scope)

1. Situation and priorities

Losses due to environmental stresses, diseases, and mortality create the need for an improved understanding of the factors affecting Montana livestock. Promoting and maintaining animal health (cattle, sheep) has led to advances in genetics, performance, and reproduction technology. To address the needs of stakeholders and those who rely on COA recommendations for animal production in the State, the following priorities have been established:

- Develop effective livestock disease control methods
- Improve beef production practices and evaluate genetics to improve herds
- Identify and mitigate the transmission of diseases between livestock and wildlife
- Increase wool and lamb competitiveness
- Implement targeted grazing strategies
- Nutritional impact of grazing on sheep and cattle

- Determine how factors, such as herd size and supplement intake, influence growth and development of cattle grazing native rangelands

Food safety and biosecurity are concerns for the beef industry at all production levels. Beef producers must address methods to improve and document ranch biosecurity and biocontainment protocols to prevent perceived food safety events and thus, irreparable harm to beef's market share.

2. Scope of the Program

- In-State Extension
- In-State Research
- Multistate Extension
- Integrated Research and Extension

V(D). Planned Program (Assumptions and Goals)

1. Assumptions made for the Program

- Funding through industry organizations, livestock associations, companies, and other agencies will continue to provide input into priorities and activities
 - Full-time staff and part-time assistants will be available to maintain appropriate progress
 - Funding and technical support will be maintained from partnering institutions and cooperators
 - Program development will proceed as planned without major interruptions

2. Ultimate goal(s) of this Program

- Discover novel vaccines for prevention of livestock diseases
- Maintain status as a leading university in animal production and rangeland stewardship research
- Provide genomic research to help Montana producers stay competitive
- Provide improved production management recommendations to Montana producers
- Produce safe, nutritious livestock products in sufficient quantity to meet U.S. and world demand

V(E). Planned Program (Inputs)

1. Estimated Number of professional FTE/SYs to be budgeted for this Program

Year	Extension		Research	
	1862	1890	1862	1890
2014	0.0	0.0	49.4	0.0
2015	0.0	0.0	49.4	0.0
2016	0.0	0.0	49.4	0.0
2017	0.0	0.0	49.4	0.0
2018	0.0	0.0	49.4	0.0

V(F). Planned Program (Activity)

1. Activity for the Program

- Create databases accessible to researchers and producers to share research results readily available
- Distribute papers and research results at state nutrition conferences, field days, county meetings, and state conventions
- Prepare research articles, fact sheets, and news releases for scientists and state media
- Hold strategic planning meetings with state agricultural groups
- Develop systems that ensure food safety and agricultural security
- Integrate, where possible, best practices for beef quality assurance in programs

2. Type(s) of methods to be used to reach direct and indirect contacts

Extension

Direct Methods	Indirect Methods
<ul style="list-style-type: none"> • Education Class • Workshop • Group Discussion • Demonstrations 	<ul style="list-style-type: none"> • Newsletters • TV Media Programs • eXtension web sites • Web sites other than eXtension

3. Description of targeted audience

- State agencies, animal health companies, and state commodity groups
- Ranchers, seedstock industry, colleagues, and related stakeholders
- Crop and livestock producers in Montana

V(G). Planned Program (Outputs)

NIFA no longer requires you to report target numbers for standard output measures in the Plan of Work. However, all institutions will report actual numbers for standard output measures in the Annual Report of Accomplishments and Results. The standard outputs for which you must continue to collect data are:

- Number of contacts
 - Direct Adult Contacts
 - Indirect Adult Contacts
 - Direct Youth Contacts
 - Indirect Youth Contact
- Number of patents submitted
- Number of peer reviewed publications

Clicking this box affirms you will continue to collect data on these items and report the data in the Annual Report of Accomplishments and Results.

V(H). State Defined Outputs

1. Output Measure

- Number of research citations
 - Number of publications on infectious disease and food safety research
 - Number of presentations on infectious disease research
 - Number of undergraduate and graduate students trained in animal science and biotechnology
- Clicking this box affirms you will continue to collect data on these items and report the data in the Annual Report of Accomplishments and Results.

V(I). State Defined Outcome

O. No	Outcome Name
1	Identify critical infection and resistance processes
2	Number of improvements to vaccines developed
3	Meetings that maintain or enhance Montana's presence in the production of quality meat products
4	Number of ranches using beef quality assurance practices to manage animal health and well-being issues

Outcome # 1

1. Outcome Target

Identify critical infection and resistance processes

2. Outcome Type : Change in Action Outcome Measure

3. Associated Knowledge Area(s)

- 303 - Genetic Improvement of Animals
- 311 - Animal Diseases
- 315 - Animal Welfare/Well-Being and Protection

4. Associated Institute Type(s)

- 1862 Research

Outcome # 2

1. Outcome Target

Number of improvements to vaccines developed

2. Outcome Type : Change in Condition Outcome Measure

3. Associated Knowledge Area(s)

- 311 - Animal Diseases
- 315 - Animal Welfare/Well-Being and Protection

4. Associated Institute Type(s)

- 1862 Research

Outcome # 3

1. Outcome Target

Meetings that maintain or enhance Montana's presence in the production of quality meat products

2. Outcome Type : Change in Knowledge Outcome Measure

3. Associated Knowledge Area(s)

- 302 - Nutrient Utilization in Animals
- 303 - Genetic Improvement of Animals

- 311 - Animal Diseases
- 315 - Animal Welfare/Well-Being and Protection
- 902 - Administration of Projects and Programs

4. Associated Institute Type(s)

- 1862 Research

Outcome # 4

1. Outcome Target

Number of ranches using beef quality assurance practices to manage animal health and well-being issues

2. Outcome Type : Change in Action Outcome Measure

3. Associated Knowledge Area(s)

- 301 - Reproductive Performance of Animals
- 302 - Nutrient Utilization in Animals
- 303 - Genetic Improvement of Animals
- 305 - Animal Physiological Processes
- 306 - Environmental Stress in Animals
- 307 - Animal Management Systems
- 308 - Improved Animal Products (Before Harvest)
- 311 - Animal Diseases
- 315 - Animal Welfare/Well-Being and Protection
- 711 - Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources

4. Associated Institute Type(s)

- 1862 Research

V(J). Planned Program (External Factors)

1. External Factors which may affect Outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Appropriations changes
- Public Policy changes
- Government Regulations

Description

- Inadequate funding and technical support from partnering institutions and cooperators
- Inadequate moisture (rainfall, irrigation, snowpack) for crops to be produced, creating excessive variability
 - Lack of full-time staff and part-time assistants
 - Major interruptions in program development
 - Reduced support from Montana crop and animal agricultural groups, conservation and wildlife groups, private industry, private donations, and other agencies

V(K). Planned Program - Planned Evaluation Studies

Description of Planned Evaluation Studies

Evaluation studies will be conducted annually through the issuance and collection of surveys, published peer review materials and secured peer reviewed grant proposals.

V(A). Planned Program (Summary)

Program # 3

1. Name of the Planned Program

Global Food Security and Hunger -- Integrated Pest Management

2. Brief summary about Planned Program

Montana's stakeholders need new and improved methods for controlling insects, weeds, and diseases. Pesticides are a major expense to producers; however delaying or eliminating pest control measures may not always be an option. An increase in public concern about food quality, natural resource biodiversity, and sustainability and quality of soil, air, and water resources is mandating less reliance on traditional pesticides and more research into biological control systems and organic food production. An emphasis on pest monitoring (using decision-making parameters and determining economic injury levels) will optimize the use of pesticides for controlling pests. Foreign trade partners especially want decreased pesticide residues in the wheat and barley exports.

Research Activities

MAES scientists initiated alfalfa hay management programs to compare traditional chemical control methods, biological controls, and cultural management options. Research into forages includes the examination of pest and natural enemy complexes and their interaction. Controlling pests (lygus, aphids, alfalfa weevils) in seed alfalfa without impacting native or managed pollinators, especially leafcutter bees, is a research priority. Improving wheat competitiveness and developing herbicide tolerance through bioengineering are priorities among researchers. Specialists are assessing the effectiveness of new and existing herbicides on Montana agricultural systems.

Research results indicate the complex interactions in managing sawfly make a total systems approach necessary to reduce damage to small grains. MSU is examining the integration of natural enemies, pathogens, and chemicals for management of sawfly and is developing new sources of host plant resistance.

Research is ongoing to find additional environmentally friendly solutions for the management of soil-borne plant pathogens. Identifying optimal disease management strategies and establishing biological controls are priorities for producing potatoes, sugar beets, small grains, and other crops in Montana. Continuing research into novel disease management systems for potatoes will reduce a grower's dependence on a single management tool for protection of their crop.

Understanding the role of weed diversity and seedbanks in Montana cropping systems will help producers develop more effective weed control programs. Increasing management for control of spotted knapweed will enhance rangeland productivity and plant diversity, while enhancing Montana's agricultural economic return and improving wildlife habitat.

3. Program existence : Mature (More than five years)

4. Program duration : Long-Term (More than five years)

5. Expending formula funds or state-matching funds : Yes

6. Expending other than formula funds or state-matching funds : Yes

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
211	Insects, Mites, and Other Arthropods Affecting Plants			27%	
212	Pathogens and Nematodes Affecting Plants			25%	
213	Weeds Affecting Plants			20%	
215	Biological Control of Pests Affecting Plants			10%	
216	Integrated Pest Management Systems			18%	
	Total			100%	

V(C). Planned Program (Situation and Scope)

1. Situation and priorities

Investigators with the COA and MAES focus on identifying and managing weeds, insects, and diseases, so the agricultural community in Montana can better impact global food security. They are also developing and sharing quality stewardship programs to identify and mitigate noxious weeds and harmful insects. Field crops are an important foundation for the Montana agricultural industry and revenue exceeded \$2 billion in 2012. The most significant crop in Montana was wheat (5.4 million acres, \$1.4 billion) followed by barley (760,000 acres, \$143 million). Montana farmers spent approximately \$15 million on fungicide applications in 2011, but the number was much less in 2012, because of drier conditions. Although yield benefits/detriments from spraying a fungicide are difficult to estimate, most respondents estimated a 0-20 percent yield increase. Not spraying resistant varieties of grain saved \$12 million. Stripe rust cost growers \$48 million in 2011. Fungicide application saved growers \$30 million. If the estimated worth of the wheat crop in Montana is \$1.6 billion, they saved 2 percent of the crop. Susceptible varieties sprayed in a timely manner saved approximately \$90 million. Savings due to herbicide and seed costs on 2,000 acres of winter wheat totaled approximately \$60,000 and yields of winter wheat averaged approximately 40 bu/acre, totaling \$480,000 (est. \$6/bu) in farm revenue.

Biological controls for insects, weeds, and diseases are becoming more important as traditional chemical control methods are limited. The increase in public concern about food quality and safety, natural resource biodiversity, and sustainability of the quality of soil, air, and water is mandating less reliance on traditional pesticides and more research into environmentally friendly systems.

Researchers with the MSU IPM programs want to:

- Address the economic feasibility and environmental impact of biological control practices
- Investigate crop rotation systems, production methods, and water management
- Implement biological control practices and explore a multitude of science-based options
- Optimize grower profitability and natural resource sustainability

2. Scope of the Program

- In-State Extension
- In-State Research
- Integrated Research and Extension

V(D). Planned Program (Assumptions and Goals)

1. Assumptions made for the Program

- Adequate moisture (rainfall, irrigation, snowpack) will be available for crops
- Full-time staff and part-time assistants will be available to maintain appropriate progress
- Funding and technical support will be maintained from partnering institutions and cooperators
- Grain and livestock associations, companies, and other agencies will continue providing input and financially support priorities and activities
 - Program development will proceed as planned without major interruptions

2. Ultimate goal(s) of this Program

- Contribute to the understanding of weed resistance through research targeting plant biochemical processes
 - Develop novel pest management systems that include biological control
 - Improve rangeland management by developing controls for exotic noxious weed species
 - Provide efficacious and cost effective pest control programs for producers

V(E). Planned Program (Inputs)

1. Estimated Number of professional FTE/SYs to be budgeted for this Program

Year	Extension		Research	
	1862	1890	1862	1890
2014	0.0	0.0	63.6	0.0
2015	0.0	0.0	63.6	0.0
2016	0.0	0.0	63.6	0.0
2017	0.0	0.0	63.6	0.0
2018	0.0	0.0	63.6	0.0

V(F). Planned Program (Activity)

1. Activity for the Program

- Disseminate information in print and online to provide pest control recommendations
- Produce regional management guides
- Conduct pesticide workshops and field days to share research results
- Support FIFRA Section 18c products labeling requests
- Update pesticide applicator training materials when necessary

- Update training materials for private and commercial pesticide applicators with new information

2. Type(s) of methods to be used to reach direct and indirect contacts

Extension

Direct Methods	Indirect Methods
<ul style="list-style-type: none"> • Education Class • Workshop • Demonstrations 	<ul style="list-style-type: none"> • Newsletters

3. Description of targeted audience

- Crop producers, dealers, distributors, and crop protection company representatives
- Crop protection companies registration and research personnel
- Montana crop advisory boards
- Private and commercial pesticide applicators
- State of Montana, Montana Department of Agriculture, BLM, USFS, and other government entities

V(G). Planned Program (Outputs)

NIFA no longer requires you to report target numbers for standard output measures in the Plan of Work. However, all institutions will report actual numbers for standard output measures in the Annual Report of Accomplishments and Results. The standard outputs for which you must continue to collect data are:

- Number of contacts
 - Direct Adult Contacts
 - Indirect Adult Contacts
 - Direct Youth Contacts
 - Indirect Youth Contact
- Number of patents submitted
- Number of peer reviewed publications

Clicking this box affirms you will continue to collect data on these items and report the data in the Annual Report of Accomplishments and Results.

V(H). State Defined Outputs

1. Output Measure

- Number of research citations
- Multidisciplinary journal articles published

- Clicking this box affirms you will continue to collect data on these items and report the data in the Annual Report of Accomplishments and Results.

V(I). State Defined Outcome

O. No	Outcome Name
1	Quality in-depth training programs for continuing education on integrated pest management
2	New IPM options discovered, evaluated, or changed/alterd
3	Passing rate percentage for pesticide application licenses
4	New products registered.

Outcome # 1

1. Outcome Target

Quality in-depth training programs for continuing education on integrated pest management

2. Outcome Type : Change in Knowledge Outcome Measure

3. Associated Knowledge Area(s)

- 211 - Insects, Mites, and Other Arthropods Affecting Plants
- 212 - Pathogens and Nematodes Affecting Plants
- 213 - Weeds Affecting Plants
- 215 - Biological Control of Pests Affecting Plants
- 216 - Integrated Pest Management Systems

4. Associated Institute Type(s)

- 1862 Research

Outcome # 2

1. Outcome Target

New IPM options discovered, evaluated, or changed/alterd

2. Outcome Type : Change in Action Outcome Measure

3. Associated Knowledge Area(s)

- 211 - Insects, Mites, and Other Arthropods Affecting Plants
- 212 - Pathogens and Nematodes Affecting Plants
- 213 - Weeds Affecting Plants
- 215 - Biological Control of Pests Affecting Plants
- 216 - Integrated Pest Management Systems

4. Associated Institute Type(s)

- 1862 Research

Outcome # 3

1. Outcome Target

Passing rate percentage for pesticide application licenses

2. Outcome Type : Change in Knowledge Outcome Measure

3. Associated Knowledge Area(s)

- 211 - Insects, Mites, and Other Arthropods Affecting Plants
- 212 - Pathogens and Nematodes Affecting Plants
- 213 - Weeds Affecting Plants
- 215 - Biological Control of Pests Affecting Plants
- 216 - Integrated Pest Management Systems

4. Associated Institute Type(s)

- 1862 Research

Outcome # 4

1. Outcome Target

New products registered.

2. Outcome Type : Change in Action Outcome Measure

3. Associated Knowledge Area(s)

- 211 - Insects, Mites, and Other Arthropods Affecting Plants
- 212 - Pathogens and Nematodes Affecting Plants
- 213 - Weeds Affecting Plants
- 215 - Biological Control of Pests Affecting Plants
- 216 - Integrated Pest Management Systems

4. Associated Institute Type(s)

- 1862 Research

V(J). Planned Program (External Factors)

1. External Factors which may affect Outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Appropriations changes
- Public Policy changes
- Government Regulations

Description

- Inadequate moisture (rainfall, irrigation, snowpack) for consistent crop production
- Inadequate funding and technical support from partnering institutions and cooperators
- Lack of full-time staff and part-time assistants for the projects
- Major interruptions in program development
- Reduced support from grain associations, companies, and other agencies

V(K). Planned Program - Planned Evaluation Studies

Description of Planned Evaluation Studies

Evaluation studies will be conducted annually through the issuance of surveys, published peer review materials, and secured peer reviewed grant proposals.

V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Global Food Security and Hunger: Plant Improvements, Genomics, and Products

2. Brief summary about Planned Program

MSU is recognized as an international leader in the development of new cultivars of wheat and barley that are sought by global buyers. An aggressive plant breeding program ensures development of higher yielding, disease- and insect-resistant wheat and barley cultivars. Many new cultivars are licensed with partnering companies, thus ensuring that Montana stakeholders receive maximum benefit from research discoveries.

Research Activities: Plant breeding, genetics, and genomics projects tend to be long-term with little change from year to year. Primary emphasis of the winter wheat breeding program is the development of improved cultivars adapted to Montana's climatic conditions and cropping systems. Research is ongoing to develop germplasm with excellent end-use qualities and resistance to important pest and environmental stresses. Researchers will evaluate more efficient screening, selection, and breeding strategies and procedures to maximize efficiency and genetic progress in winter wheat breeding. Research projects will develop new hard red spring wheat cultivars for Montana producers, contribute to the science of wheat breeding and genetics, and improve end-use characteristics. The broader impacts of MSU research are a larger food supply for the world, an improved ability of Montana farmers to compete in a global marketplace, and a strengthening of export markets for U.S. wheat. The primary output of the wheat improvement program is release of improved winter wheat cultivars. Cultivar performance data is disseminated to wheat producers via the internet, traditional extension bulletins, and in popular farm press publications.

Barley cultivars with improved feed quality could provide sustainable seed and grain markets for regional grain producers, and provide marketing advantages to regional beef producers. Research is being conducted on the development of lines for the malting, feed, and ethanol industries. The development and distribution of high quality, drought tolerant barley cultivars that provide the highest production potential is a priority of barley breeding programs. We have increased our understanding of the genetic control of traits like winter hardiness, feed quality, malting quality, and drought tolerance. Our multi-state barley research focuses the disciplines of plant breeding, genetics, plant pathology, cereal science, molecular biology, and genomics for barley improvement in Idaho, Montana, and North Dakota. We recently released four feed, forage, and malt barley cultivars that fit Montana's production environments and that provide added value to Montana barley growers and to growers throughout the Northern Plains. MSU is developing multiple pest-resistant dryland alfalfa cultivars with good agronomic traits for Montana. In addition to alfalfa projects, efforts have been made to develop new grass cultivars suitable for Montana.

Several new camelina products are being developed for use in bread, as soil amendments, and to produce omega-3 rich beef and pork. We anticipate that new high-tocopherol lines of safflower will add value to producers in eastern Montana and western North Dakota and provide a more nutritious product.

Researchers are exploring different crops that deliver specific value-added products to consumers. The research involves identifying consumer needs not met by current crops. Through the project scientists intend to continue development of camelina, timtana, proatina and montina, and expand marketability and profitability to farmers. The impacts of Proatina and Timtana products have been considerable in the health food market, because they are gluten free and part of a \$2.5 billion annual market. Acreage of

production has risen each year. The laboratory and analytical chemistry resources devoted to this project are a key reason why these products are on the market and contributing to the general health of the gluten intolerant and gluten sensitive population, now comprising about 6 percent of the population.

Another scientist with ImID is studying food quality and metabolic parameters influencing development and progression of fatty liver disease (FLD) which impacts tens-of-millions of Americans and can progress to liver cirrhosis. This proposal is aimed at understanding the genetic, metabolic, and systemic physiological processes that underlie FLD. The goal is to understand the pathways leading to FLD and eventually design dietary, food-source, or food supplement protocols that might eliminate or abrogate the physical manifestations of FLD. This work will test whether simple shifts in the nation's food supply or in the USDA's nutritional recommendations might be effective at reducing FLD in the U.S. From an agricultural perspective, this might mean that subtle shifts in production of might increase the general health of Americans.

3. Program existence : Intermediate (One to five years)

4. Program duration : Long-Term (More than five years)

5. Expending formula funds or state-matching funds : Yes

6. Expending other than formula funds or state-matching funds : Yes

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms			15%	
202	Plant Genetic Resources			30%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			10%	
204	Plant Product Quality and Utility (Preharvest)			15%	
205	Plant Management Systems			10%	
502	New and Improved Food Products			5%	
701	Nutrient Composition of Food			2%	
702	Requirements and Function of Nutrients and Other Food Components			1%	
703	Nutrition Education and Behavior			1%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			5%	
723	Hazards to Human Health and Safety			1%	
903	Communication, Education, and Information Delivery			5%	
	Total			100%	

V(C). Planned Program (Situation and Scope)

1. Situation and priorities

An aggressive plant breeding program ensures development of higher yielding disease-resistant and insect-resistant wheat and barley cultivars. Much of the North Dakota/Minnesota Red River Valley malting barley production is moving to Montana and Idaho, increasing the level of research needed to provide cultivars suitable for Montana growing conditions. Additional work in the development of alternative crops continues to produce potential new market opportunities for Montana producers. Commercial buyers from Asian countries assess hard red spring wheats and hard red winter wheats for use in making noodles, steam bread, and loaves. Wheat cultivars developed at MSU and grown commercially by Montana producers continue to rank in the most preferred category by international customers. Producing high quality safe crops in abundant supply requires strict adherence to pesticide laws, to appropriate interfaces with biotechnology, and to timing of the storage and marketing of commodities. Priorities in the Plant Breeding, Genomics, and Products Program Area include:

- Increase yield potentials and maintain/improve quality
- Improve winter hardiness, wheat stem sawfly resistance, and imidazolinone herbicide tolerance
- Integrate genomic research into breeding programs
- Provide improved cultivars of small grains adapted to Montana climatic conditions and cropping systems

2. Scope of the Program

- In-State Extension
- In-State Research
- Multistate Research

V(D). Planned Program (Assumptions and Goals)

1. Assumptions made for the Program

- Adequate moisture (rainfall, irrigation, snowpack) will be available for crops
- Funding from industry organizations, grain and livestock associations, companies, and other agencies will provide input into priorities and activities
- Full-time staff and part-time assistants will be available to maintain appropriate progress
- Funding and technical support from partnering institutions and agricultural groups will be maintained
- Montana businesses and state agencies will be interested in commercialization opportunities
- Program development will proceed as planned without major interruptions

2. Ultimate goal(s) of this Program

- Increase yield potential for small grain production in Montana
- Maintain our role as a leading university in wheat and barley genetics research
- Provide genomic research that will help Montana producers stay competitive
- Provide improved cultivars of wheat and barley to Montana producers
- Produce crops that are safe, nutritious, and in sufficient quantity to meet the needs of U.S. and world consumers
- Support food risk assessment education and research

V(E). Planned Program (Inputs)

1. Estimated Number of professional FTE/SYs to be budgeted for this Program

Year	Extension		Research	
	1862	1890	1862	1890
2014	0.0	0.0	72.9	0.0
2015	0.0	0.0	72.9	0.0
2016	0.0	0.0	72.9	0.0
2017	0.0	0.0	72.9	0.0
2018	0.0	0.0	72.9	0.0

V(F). Planned Program (Activity)

1. Activity for the Program

- Communicate information on plant breeding and genomics advances through classroom activities, field days, cultivar trials, news releases, presentations at county and state meetings, and conventions
- Release germplasm, new cultivars, and new genomics tools and techniques
- Conduct strategic planning with state agricultural groups
- Write technical and non-technical publications
- Develop value-added, agriculturally based end-use products
- Establish biobased product and food science education and research programs
- Enhance partnerships among faculty across the Montana university system, producers, agricultural industry, and other educational institutions across the region
 - Provide ways to enhance agricultural production practices to enhance product quality
 - Develop research summaries and fact sheets

2. Type(s) of methods to be used to reach direct and indirect contacts

Extension

Direct Methods	Indirect Methods
<ul style="list-style-type: none"> • Education Class • Workshop • Group Discussion • Demonstrations 	<ul style="list-style-type: none"> • Public Service Announcement • Newsletters • Web sites other than eXtension • Other 1 (Variety Recommendation Bulletins)

3. Description of targeted audience

- Domestic and foreign buyers of quality wheat
- Farmers, colleagues, and stakeholders
- Grain associations, Montana Department of Agriculture, Montana Wheat and Barley Committee, grain elevators, and state commodity groups

- Seed companies
- Crop and livestock producers in Montana
- State agricultural advisory committees
- Economic development groups
- Participants in extension and commodity group meetings, conventions, conferences, and field days
- State of Montana, Montana Department of Agriculture, BLM, USFS, and other government entities

V(G). Planned Program (Outputs)

NIFA no longer requires you to report target numbers for standard output measures in the Plan of Work. However, all institutions will report actual numbers for standard output measures in the Annual Report of Accomplishments and Results. The standard outputs for which you must continue to collect data are:

- Number of contacts
 - Direct Adult Contacts
 - Indirect Adult Contacts
 - Direct Youth Contacts
 - Indirect Youth Contact
- Number of patents submitted
- Number of peer reviewed publications

Clicking this box affirms you will continue to collect data on these items and report the data in the Annual Report of Accomplishments and Results.

V(H). State Defined Outputs

1. Output Measure

- Number of foreign trade teams at MSU
- Number of research citations

Clicking this box affirms you will continue to collect data on these items and report the data in the Annual Report of Accomplishments and Results.

V(I). State Defined Outcome

O. No	Outcome Name
1	Number of new or improved cultivar recommendations provided to Montana producers to maintain dominance in small grain markets
2	Integration of new molecular techniques into breeding projects to improve outcomes
3	Average per bushel yield increase of Montana grains while maintaining product quality
4	Number of elite lines of wheat and barley screened for agronomic and quality characteristics
5	Planted acreage percentage increase per year of new MSU-released small grains in Montana
6	Number of new food products created from Montana crops

Outcome # 1

1. Outcome Target

Number of new or improved cultivar recommendations provided to Montana producers to maintain dominance in small grain markets

2. Outcome Type : Change in Condition Outcome Measure

3. Associated Knowledge Area(s)

- 201 - Plant Genome, Genetics, and Genetic Mechanisms
- 202 - Plant Genetic Resources
- 203 - Plant Biological Efficiency and Abiotic Stresses Affecting Plants
- 204 - Plant Product Quality and Utility (Preharvest)

4. Associated Institute Type(s)

- 1862 Research

Outcome # 2

1. Outcome Target

Integration of new molecular techniques into breeding projects to improve outcomes

2. Outcome Type : Change in Condition Outcome Measure

3. Associated Knowledge Area(s)

- 201 - Plant Genome, Genetics, and Genetic Mechanisms
- 202 - Plant Genetic Resources
- 203 - Plant Biological Efficiency and Abiotic Stresses Affecting Plants
- 204 - Plant Product Quality and Utility (Preharvest)

4. Associated Institute Type(s)

- 1862 Research

Outcome # 3

1. Outcome Target

Average per bushel yield increase of Montana grains while maintaining product quality

2. Outcome Type : Change in Condition Outcome Measure

3. Associated Knowledge Area(s)

- 201 - Plant Genome, Genetics, and Genetic Mechanisms
- 202 - Plant Genetic Resources
- 204 - Plant Product Quality and Utility (Preharvest)
- 205 - Plant Management Systems

4. Associated Institute Type(s)

- 1862 Research

Outcome # 4

1. Outcome Target

Number of elite lines of wheat and barley screened for agronomic and quality characteristics

2. Outcome Type : Change in Condition Outcome Measure

3. Associated Knowledge Area(s)

- 201 - Plant Genome, Genetics, and Genetic Mechanisms
- 202 - Plant Genetic Resources
- 203 - Plant Biological Efficiency and Abiotic Stresses Affecting Plants
- 204 - Plant Product Quality and Utility (Preharvest)
- 205 - Plant Management Systems

4. Associated Institute Type(s)

- 1862 Research

Outcome # 5

1. Outcome Target

Planted acreage percentage increase per year of new MSU-released small grains in Montana

2. Outcome Type : Change in Condition Outcome Measure

3. Associated Knowledge Area(s)

- 201 - Plant Genome, Genetics, and Genetic Mechanisms
- 202 - Plant Genetic Resources
- 203 - Plant Biological Efficiency and Abiotic Stresses Affecting Plants
- 204 - Plant Product Quality and Utility (Preharvest)

- 205 - Plant Management Systems

4. Associated Institute Type(s)

- 1862 Research

Outcome # 6

1. Outcome Target

Number of new food products created from Montana crops

2. Outcome Type : Change in Action Outcome Measure

3. Associated Knowledge Area(s)

- 205 - Plant Management Systems
- 502 - New and Improved Food Products
- 903 - Communication, Education, and Information Delivery

4. Associated Institute Type(s)

- 1862 Research

V(J). Planned Program (External Factors)

1. External Factors which may affect Outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Other (Funding)

Description

- Inadequate funding and technical support from partnering institutions and cooperators
- Inadequate moisture (rainfall, irrigation, snowpack) for reliable and consistent crop production
- Lack of full-time staff and part-time assistants for the projects
- Major interruptions in program development
- Reduced support from Montana crop and animal agricultural groups, conservation and wildlife groups, private industry, private donations, and other agencies

V(K). Planned Program - Planned Evaluation Studies

Description of Planned Evaluation Studies

Evaluation studies will be conducted annually through the issuance of surveys, published peer review materials and secured peer reviewed grant proposals. Additionally, information will be obtained from field days, conversations, direct input, and annual funding discussions with the Montana Wheat and Barley Committee.

V(A). Planned Program (Summary)

Program # 5

1. Name of the Planned Program

Global Food Security and Hunger: Animal Health, Production, and Products

2. Brief summary about Planned Program

Montana ranchers contributed five percent of the U.S. total beef cow production in 2012 and six percent of the U.S. lamb production. As the market becomes more global it is important that agricultural production meets the growing food demand. Research programs at MSU COA and MAES focus on reproductive performance in animals, nutrition, genetic improvements for herds, and developing better animal management systems.

3. Program existence : Mature (More than five years)

4. Program duration : Long-Term (More than five years)

5. Expending formula funds or state-matching funds : Yes

6. Expending other than formula funds or state-matching funds : No

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
121	Management of Range Resources			5%	
301	Reproductive Performance of Animals			12%	
302	Nutrient Utilization in Animals			10%	
303	Genetic Improvement of Animals			10%	
304	Animal Genome			10%	
305	Animal Physiological Processes			10%	
306	Environmental Stress in Animals			5%	
307	Animal Management Systems			10%	
308	Improved Animal Products (Before Harvest)			12%	
311	Animal Diseases			5%	
315	Animal Welfare/Well-Being and Protection			5%	
702	Requirements and Function of Nutrients and Other Food Components			3%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources			3%	
	Total			100%	

V(C). Planned Program (Situation and Scope)**1. Situation and priorities**

Losses due to environmental stresses, diseases, and mortality create the need for an improved understanding of the factors affecting Montana livestock. Promoting and maintaining animal health (cattle, sheep, and wildlife) has led to advances in genetics, performance, and reproduction technology. To address the needs of stakeholders and those who rely on MSU COA recommendations for animal production in the State, researchers established the following priorities:

- Manage environmental stress in animals during the winter, lower production costs, and improve livestock genetics
- Develop and implement new management protocols and/or pharmaceutical and nutritional regimens to improve health, performance, and fertility of domestic ruminants
- Determine how factors, such as herd size and supplement intake, influence growth and development of cattle grazing native rangelands
- Understand and develop new treatments for infectious diseases of livestock

2. Scope of the Program

- In-State Extension
- In-State Research
- Multistate Research

V(D). Planned Program (Assumptions and Goals)

1. Assumptions made for the Program

- Funding through industry organizations, livestock associations, companies, and other agencies will continue to provide input into priorities and activities
 - Full-time staff and part-time assistants will be available to maintain appropriate progress
 - Funding and technical support will be maintained from partnering institutions and cooperators
 - Program development will proceed as planned without major interruptions

2. Ultimate goal(s) of this Program

- Maintain role as a leading university in animal production and rangeland stewardship research
- Provide genomic research that will help Montana producers stay competitive
- Provide improved production management recommendations to Montana producers
- Produce livestock products that are safe, nutritious, and in sufficient quantity to meet the needs of U.S. and world consumers

V(E). Planned Program (Inputs)

1. Estimated Number of professional FTE/SYs to be budgeted for this Program

Year	Extension		Research	
	1862	1890	1862	1890
2014	0.0	0.0	49.0	0.0
2015	0.0	0.0	49.0	0.0
2016	0.0	0.0	49.0	0.0
2017	0.0	0.0	49.0	0.0
2018	0.0	0.0	49.0	0.0

V(F). Planned Program (Activity)

1. Activity for the Program

- Conduct research regarding livestock reproduction and fertility rates and share results timely with producers
 - Enhance the value of animal products, primarily sheep and beef cattle
 - Explore the nutritional managements systems for livestock and winter grazing

- Continue advanced research for targeted grazing management
- Maintain research on residual feed intake and feed to gain conversion
- Conduct research on livestock infectious diseases

2. Type(s) of methods to be used to reach direct and indirect contacts

Extension

Direct Methods	Indirect Methods
<ul style="list-style-type: none"> • Education Class • Workshop • Group Discussion • Demonstrations 	<ul style="list-style-type: none"> • Billboards • Newsletters • TV Media Programs • eXtension web sites • Web sites other than eXtension

3. Description of targeted audience

- State agencies, animal health companies, and state commodity groups
- Ranchers, seedstock industry, colleagues, and related stakeholders
- Crop and livestock producers in Montana

V(G). Planned Program (Outputs)

NIFA no longer requires you to report target numbers for standard output measures in the Plan of Work. However, all institutions will report actual numbers for standard output measures in the Annual Report of Accomplishments and Results. The standard outputs for which you must continue to collect data are:

- Number of contacts
 - Direct Adult Contacts
 - Indirect Adult Contacts
 - Direct Youth Contacts
 - Indirect Youth Contact
 - Number of patents submitted
 - Number of peer reviewed publications
- Clicking this box affirms you will continue to collect data on these items and report the data in the Annual Report of Accomplishments and Results.

V(H). State Defined Outputs

1. Output Measure

- Provide translational research to producers through outreach and Extension programs.
- Publish research in scientific journals.
- Present research findings to the public and interested producers through seminars and workshops.
- Clicking this box affirms you will continue to collect data on these items and report the data in the Annual Report of Accomplishments and Results.

V(I). State Defined Outcome

O. No	Outcome Name
1	Number of off-campus educational programs offered
2	Determine management factors that affect animal products
3	Disseminate research program results to producers regarding invasive weed management and impact on livestock
4	Find genetic correlations of factors influencing residual feed intake and feed efficiency

Outcome # 1

1. Outcome Target

Number of off-campus educational programs offered

2. Outcome Type : Change in Knowledge Outcome Measure

3. Associated Knowledge Area(s)

- 301 - Reproductive Performance of Animals
- 302 - Nutrient Utilization in Animals
- 303 - Genetic Improvement of Animals
- 304 - Animal Genome
- 305 - Animal Physiological Processes
- 306 - Environmental Stress in Animals
- 307 - Animal Management Systems
- 308 - Improved Animal Products (Before Harvest)

4. Associated Institute Type(s)

- 1862 Research

Outcome # 2

1. Outcome Target

Determine management factors that affect animal products

2. Outcome Type : Change in Knowledge Outcome Measure

3. Associated Knowledge Area(s)

- 121 - Management of Range Resources
- 301 - Reproductive Performance of Animals
- 302 - Nutrient Utilization in Animals
- 303 - Genetic Improvement of Animals
- 304 - Animal Genome
- 305 - Animal Physiological Processes
- 306 - Environmental Stress in Animals
- 307 - Animal Management Systems
- 311 - Animal Diseases

4. Associated Institute Type(s)

- 1862 Research

Outcome # 3

1. Outcome Target

Disseminate research program results to producers regarding invasive weed management and impact on livestock

2. Outcome Type : Change in Knowledge Outcome Measure

3. Associated Knowledge Area(s)

- 121 - Management of Range Resources
- 302 - Nutrient Utilization in Animals
- 307 - Animal Management Systems
- 308 - Improved Animal Products (Before Harvest)
- 315 - Animal Welfare/Well-Being and Protection
- 702 - Requirements and Function of Nutrients and Other Food Components
- 711 - Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources

4. Associated Institute Type(s)

- 1862 Research

Outcome # 4

1. Outcome Target

Find genetic correlations of factors influencing residual feed intake and feed efficiency

2. Outcome Type : Change in Knowledge Outcome Measure

3. Associated Knowledge Area(s)

- 301 - Reproductive Performance of Animals
- 302 - Nutrient Utilization in Animals
- 303 - Genetic Improvement of Animals
- 304 - Animal Genome
- 308 - Improved Animal Products (Before Harvest)
- 315 - Animal Welfare/Well-Being and Protection
- 702 - Requirements and Function of Nutrients and Other Food Components

- 711 - Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources

4. Associated Institute Type(s)

- 1862 Research

V(J). Planned Program (External Factors)

1. External Factors which may affect Outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations

Description

- Inadequate funding and technical support from partnering institutions and cooperators
- Inadequate moisture (rainfall, irrigation, snowpack) for crops to be produced, creating excessive variability
 - Lack of full-time staff and part-time assistants
 - Major interruptions in program development
 - Reduced support from Montana crop and animal agricultural groups, conservation and wildlife groups, private industry, private donations, and other agencies

V(K). Planned Program - Planned Evaluation Studies

Description of Planned Evaluation Studies

Evaluation studies will be conducted through the issuance and collection of surveys, published peer reviewed materials and secured peer reviewed grants.