

2009 Montana State University Research Plan of Work

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I. Plan Overview

1. Brief Summary about Plan Of Work

Montana State University

2008 — 2012 Plan of Work

1. Executive Summary

Situation: Montana is a rural state with a land area of 93 million acres and a population of 944,000. Farms and ranches represent over 64% of the land in Montana. Montana ranks 2nd in the U.S. in the number of acres devoted to agricultural enterprises with crop and livestock industry annual cash receipts over \$2.3 billion. Montana ranks 3rd in the production of barley, 3rd in wheat, and 6th in sugar beets. With the support of advances in Montana State University (MSU) Agricultural Experiment Station research, Montana has moved up in the ranking of specialty crop production to 1st in Austrian winter peas, 2nd in dry edible peas, 2nd in flaxseed, 2nd in lentils, and 3rd in canola. An increase in organic wheat, barley, and Kamut grain demonstrates new initiatives. Montana beekeepers accounted for five percent of the nation's honey in 2005, placing Montana sixth among states in U.S. honey production. In 2006, Montana had over 28,000 farms and ranches with 60 million acres dedicated to agriculture. Nearly nine million acres were cropped and the remaining 51 million acres were grazed or used for other agricultural purposes. Small grains represented about 72% of the cropped acres, alfalfa and other hay 26%, and other crops 2%. Wheat and barley represent about 33% of the total agricultural receipts for the state. Over 84% of Montana's raw commodities are exported out of the state. Montana moved up to 3rd among states exporting wheat and products for fiscal year 2006. Montana ranks 11th among U.S. states in the production of cattle and 7th in the production of sheep and lambs. Cattle and calves represent over 88% of the livestock receipts for the state and 54% of the total agricultural receipts for the state. Higher prices in 2007 for beef, wheat, and barley raised farm and ranch incomes; however input costs continue to escalate challenging Montana enterprises to increase efficiencies and evaluate new markets. The production of camelina (*Camelina sativa*) in Montana has increased from 450 acres in 2005 to nearly 50,000 acres in 2007. Camelina is used for biodiesel manufacturing and high-value omega-3 markets, especially pet and livestock feed.

The College of Agriculture (COA) (six departments and one division) at MSU is headquartered in Bozeman, MT, and is comprised of the Montana Agricultural Experiment Station (MAES) and the College's academic programs (5 departments and one division) in undergraduate and graduate studies. The MAES system is a network of eight Agricultural Research Centers, four farms, and two collaborative research programs with USDA-ARS. In addition, Extension Specialists are in the COA in five of seven units. Extension efforts are generally reported separately.

Expanded partnerships include the Montana Extension Service, MSU-Billings, MSU-College of Technology at Great Falls, MSU-Northern at Havre, the 1994 Land Grant tribal colleges, and other state, federal and private institutions in Montana and the region (e.g. North Dakota State University, South Dakota State University, University of Idaho, and the University of Wyoming).

Native Americans represent the largest group of potentially underserved citizens in Montana. MSU works with tribal councils, colleges in the Rocky Mountain region, and educators to provide programs and educational opportunities for this group of Montana citizens.

Groundbreaking for the new Animal Bioscience Complex is expected in mid 2008. The complex represents the single most important project to Montana's livestock industry in decades. The facility will provide advanced research laboratories, support rooms, and classrooms. The new facilities will give students access to the latest in research, teaching and outreach in animal and range sciences.

Priorities: As a result of the stakeholder input meetings, focus groups and ongoing general interactions, MAES receive specific suggestions and ongoing support for research and outreach activities. These are:

- Add value to Montana's high quality crop and livestock products
- Create new business opportunities for rural communities
- Develop higher yielding solid stem wheat varieties
- Enhance the development of agronomically sound hard white wheat
- Expand research on agricultural and natural resource interactions
- Explore alternative and new crops
- Evaluate barley cultivars in feeding studies to demonstrate their effect on improving feed efficiency and reducing feed costs
- Improve beef production practices and use genetics to improve herds
- Increase research programs on alternative energy sources, including crops for biofuel production
- Provide better marketing of applied research results

Other areas of research that receive responses in the high priority rating are animal and livestock diseases, crop production and management, livestock production and management, natural resources, noxious weed management, nutrition and health, and range production and management. These results will likely continue to influence MAES research priority areas in the next decade.

Input Section: Stakeholder input has been solicited in the strategic planning process and is continually reaffirmed as

programs are developed, implemented, and changed and as dollars are allocated and reallocated. The COA and MAES have 28 advisory committees and boards with more than 250 members. These include: The Animal and Range Science Advisory Committee, Animal Biosciences Complex Board, Biobased Product Institute, Center for Invasive Plant Management Board, Center for Invasive Plant Management Science Advisory Council, Central Agricultural Research Center Advisory Committee, Eastern Agricultural Research Center Advisory Committee, Equine Advisory Committee, Foundation Seed Advisory Committee, Joe Skeen Institute for Rangeland Restoration, MAES State Advisory Council, Mint Committee, Montana Agricultural Innovation Center Board, Montana Beef Advisory Committee, Montana Beef Network Advisory Committee, Montana Farmers Union, Montana Pulse Growers Association, Montana Seed Growers Association Board, Montana Wool Growers Advisory Committee, Northern Agricultural Research Center Advisory Committee, Northwest and Western Agricultural Research Centers Advisory Committee, Organic Certification Association of Montana, Potato Certification Board, Southern Agricultural Research Center Advisory Committee, Thermal Biology Institute Scientific Advisory Board, Undaunted Stewardship Guidance Council, Variety Release and Recommendation Committee, and Western Triangle Advisory Committee.

Members of these committees represent farmers and ranchers, tribal councils, county extension agents, financial organizations, communities, scientists, agricultural educators, private citizens, small businesses, conservation groups, reservation groups, and agricultural organizations. The COA and its MAES faculty respond to input from these stakeholders and state/national/international trends by continually developing new programs. Faculty members also serve on local and state committees.

Inputs/Funding: The source of funds contributing to the research conducted by MAES faculty include, but are not limited to: BIA, BLM, Canadian Provinces, conservation and wildlife groups, Montana Board of Research and Commercialization Technology, 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, other states, overhead investments from sponsored programs, private donations, private industry, the State of Montana, USDA, USEPA, and USFS.

Outcomes and Impacts:

Enhance Economically Viable and Sustainable Agricultural Systems

- Contribute to commodity and product marketing and economic development
- Create comprehensive programs that address issues and problems associated with plant and animal systems
- Develop competitive, sustainable, and viable plant and animal systems
- Enhance our understanding of rural, urban, and disturbed landscapes
- Expand stewardship practices
- Foster the development of value-added biobased products
- Improve food safety and quality
- Improve plant and animal health through integrated pest management (IPM) and other sustainable practices
- Improve the fundamental understanding of plant and animal biology

Strengthen the Quality of Life for Montana and Its People

- Create opportunities for undergraduate and graduate students to engage in research
- Develop partnerships to enhance business and community development
- Facilitate the development of educational programs and new delivery systems
- Improve recruitment and retention of students

Each of the seven agricultural research centers holds annual field days in cooperation with USDA-ARS for the presentation of research information through outreach activities and to collect input on new research directions. These field days are attended by agricultural clientele, elected officials, and the general public with participation by faculty, staff, and students.

Program Areas

Agronomic and Forage Crops

Situation: Montana's limited water resources and short growing season requires researchers to be innovative in their approach to crop and pest management. Small grains, forages, and short season specialty crops make up the bulk of the cropping activity in Montana. Our long-term strategies are designed to ensure that Montana agricultural products are more desirable in U.S. and world markets. The development of high-value, alternative crops involves close collaboration among research and extension faculty in neighboring states.

Priorities: One of the major environmental challenges in Montana is the creation of better rangeland management in concert with the preservation of riparian habitats, wildlife, and clean water. Projects in agronomic and forage research at MSU have objectives that interconnect with objectives in plant and animal genomics, biobased products, and sustainable agriculture. Montana consistently grows high quality, disease-free seed potatoes for export to potato producing areas. Maintaining this status and exploring other sustainable disease-free seed production opportunities are priorities. Higher disease and insect resistance in wheat and barley, greater nutritional value for forages, and more efficient use of natural resources (especially water) are key priorities. The establishment of new value-added crops and the development of higher yielding crop varieties are

priorities among agronomic researchers. The management of rangeland for grazing livestock continues to be a priority among Montana livestock producers.

Inputs: Summaries of survey information from the Montana weed coordinators have identified critical research needs in the management of invasive plants on private, public, and agency lands. This has led to new state funding, research, and educational initiatives that align with the multi-agency and citizen-supported Montana Weed Management Plan. The Montana Wheat and Barley Committee provides financial support to MAES scientists through a competitive grant process. This financial support helps direct research programs in improving the quality of spring/winter wheat and barley, and the use of improved IPM practices. The Montana Noxious Weed Trust Fund provides funds for cooperative community watershed projects and for competitive education and research funds for COA/MAES scientists. A recently implemented pulse crop checkoff will provide research funds.

Research Activities: Surveys at Montana farm conferences indicated a strong interest in diversified crop rotations. Crop diversity studies continue to show promise for increasing on-farm receipts while reducing a monoculture of small grains. Winter and spring peas, canola, corn, lentil, mustard, sunflower, triticale, and chickpea are included in long-term rotation studies. An increased focus on the production of geranium, thyme, and sage is being made for transitioning from peppermint oil production to other essential oils. Barley varieties with improved feed quality could provide sustainable seed and grain markets for regional grain producers and marketing advantages to regional beef producers. Additionally, the use of reduced tillage and no-till systems are being evaluated to demonstrate their sustainability. Studies in precision agriculture have led to the development of a tool for a rapid nondestructive characterization of soils for a variety of environmental and agricultural applications. This process could dramatically increase the availability of soil data for monitoring carbon sequestration in agricultural lands.

Shrubs are critical in land management decision-making, although their ecological role is not well understood. Successional patterns of sagebrush communities are being researched to determine their role in ecological management, especially in relation to fire recovery. Grazing and fire recovery in rangelands are priority issues to be studied in Montana, Yellowstone National Park (YNP) and Wyoming. Determining succession patterns of sagebrush communities and their interaction with wildlife will help determine priorities for natural resource managers. Incorporating remotely sensed imagery for mapping is providing YNP personnel greater detail for updating range maps of the national park, while reducing on-ground evaluation efforts by 50% or more. Other research in YNP is looking at the adaptation and diversity of cyanobacteria in thermal areas including their potential use for cleaning up hydrocarbon polluted sites.

Livestock grazing practices are receiving increasing attention because of perceived negative impacts on soils, biodiversity, and water quality. By determining the grazing behavior by cattle and their subsequent response, decisions can be made on the need for supplemental feed over winter months. Understanding the effect of solar radiation in the selection of winter grazing ranges can help improve a cow's ability to conserve energy in winter. An evaluation of the effectiveness of livestock distribution practices on grazed watersheds is a part of an ongoing project that includes MSU, University of California (Davis), Oregon State University, and the USDA-ARS. Research from this project has shown the potential to manipulate cattle grazing patterns to protect and improve fishery and wildlife habitat. Research from Montana suggests that herding can also be a very effective approach to protecting riparian areas. The combination of herding and strategic supplement placement can potentially focus cattle grazing on upland areas that typically receive little use. Because ranching enterprises make major contributions to wildlife habitat, their viability is important to the preservation of wildlife habitat. A grazing study was completed to evaluate the effect of using goats and sheep as a cost effective strategy for controlling conifers that have encroached upon much of Montana's rangeland. This information will help refine browsing prescriptions and better enable range and livestock managers to effectively use prescribed browsing as a tool.

Animal Health

Situation: 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. Tracking livestock through the production chain can add substantially to the cost of production for producers. Infectious disease can cause considerable losses for producers by reducing production and by reducing sales due to food safety concerns. A focus on disease management, reproduction, and carcass traits will help ensure that Montana meat products maintain the highest standards. Promoting and maintaining animal health (cattle, sheep, and wildlife) has led to advances in genetics, performance, and reproduction success. By understanding immune systems and parasite development in livestock, and by developing novel genes and new biochemical routes of activity for drugs and vaccines, economically important diseases, such as coccidiosis, shipping fever, and brucellosis may be managed more effectively.

Priorities: Research programs that increase the quality of meat, milk, and fiber products continue to be a major focus of research. Disease management and research are a primary research focus. Animal losses due to environmental stresses, disease, and death create the need for an improved understanding of the factors affecting Montana livestock. A major effort is being made directed to identify alternative solutions to reducing the cost of animal identification technology. Producers need to grow their profit potential for Montana to maintain or exceed its current national ranking and reputation in the cattle and sheep industry.

Input: Stakeholder input has been solicited in the strategic planning process and continues as programs are developed, implemented and changed, and as dollars are allocated and reallocated. Valuable input has come from The Animal Biosciences Complex Board, Northern Agricultural Research Center Advisory Committee, Montana Beef Advisory Committee, Montana Beef Network Advisory Committee, Montana Wool Growers Advisory Committee, USDA ARS, and other organizations that have a vital interest in livestock production in Montana.

Research Activities: Cattle research focuses on disease control, reproductive enhancement, and animal productivity. Over 150,000 "drug-like" candidates have been screened for their activity against agonists in cattle. MSU studies have been designed to optimize mucosal and systemic antibody responses in heifers to provide passive immunity to newborn calves that are especially susceptible to scours. The efficacy of vaccines available for many bovine respiratory viruses is inconsistent. Investigating the mechanisms by which calves resist lung infections will help us better understand why these calves become susceptible to infection. MSU is testing a mucosal vaccine delivery system to provide the basis for a future generation of ruminant vaccines. Programs are in place to investigate vaccines for rotavirus, which is the major viral cause of diarrhea in cattle and costs the industry \$500 million per year.

Prion diseases, such as bovine spongiform encephalopathy (BSE) in cattle, scrapie in sheep, and chronic wasting disease (CWD) in deer and elk, are caused by novel infectious agents and results in fatal degeneration of the central nervous system. Research is being conducted to define the pathway of prion agents following infection to improve our understanding of how it spreads within a host.

Research continues in the development of vaccines for *Mycobacterium avium* ssp. *paratuberculosis* that is the causative agent of Johne's disease, which infects an estimated 22% of commercial beef and dairy cattle herds in the U.S. and results in production losses of nearly \$250 million annually. Host-pathogen interactions are being studied to understand the causes and pathways of the disease. Herpes viruses are a group of viruses that establish life-long, persistent infections in a wide range of animals, including chickens, horses, pigs, catfish, and cattle. MSU is working to develop a universal strategy for developing improved live vaccines against herpes viruses.

The annual cost of coccidiosis to livestock producers is in the hundreds of millions of dollars. The discovery of novel proteins that are essential to cell division will have a significant impact on the identification of new drug and vaccine targets for this disease. Because of bluetongue presence in Montana, Canadian trade restrictions prevent shipping feeder cattle from Montana to Canada outside of the non-fly season (March–October). Study results have demonstrated that transmission in Montana is not an issue and cattle shipments should not be subjected to trade restrictions. Despite improved dairy herd management, mastitis still represents one of the costliest diseases of the dairy industry. MSU researchers are seeking to develop a better understanding of mammary defense mechanisms in order to establish effective therapeutic approaches. A thorough understanding of the bovine NADPH oxidase at the molecular level could eventually lead to the development of therapies or strategies for enhancing leukocyte host defense processes and preventing inflammatory diseases in livestock. Research is continuing in collaboration with researchers at the University of Montana and the NIH Rocky Mountain Lab to form a center for studying emerging infectious diseases in wildlife and livestock.

The development and implementation of new management protocols and/or pharmaceutical and nutritional regimens that will increase conception rates and reduce embryo and fetal losses are collaborative goals in the Western region. Understanding the breeding characteristics and activity of bulls and synchronizing estrus in cows will lead to improved efficiency in controlling the breeding process. Various hormone releasing drugs are being evaluated to improve pregnancy rates.

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 traits, including disease resistance and increased production. Beef Quality Assurance (BQA) education and certification of Montana producers is an ongoing project for the Montana Beef Network. Educational programs on the National Animal Identification System, premises registration, BQA practices, voluntary beef cattle marketing options, and ranch management issues are offered throughout the state via meetings and interactive technologies. Programs that focus on management, nutrition, and health maintenance have been developed that provide cow-calf producers in Montana the tools to produce safe beef and improve the quality of the beef that is raised. MAES researchers have collaborated to develop a functional genomics program to study bovine immune cells.

The Montana Sheep Institute (MSI) is a cooperative project between Montana Wool Growers Association and MSU dedicated to developing and implementing non-traditional strategies that will increase the competitiveness of Montana's lamb and wool in the world market. Our goal is to explore integrated pest management (IPM) opportunities to increase the use of sheep in weed management programs, to improve the profitability and competitiveness of the Montana sheep industry, and to provide marketing opportunities for Montana sheep producers. Research is demonstrating that improved nutrition is a major factor that can reduce lamb mortality and improve profitability. Sheep grazing studies have been initiated in 10 sites involving over 100,000 acres of weed-infested rangeland and over 1000 landowners to determine the feasibility of controlling invasive weeds without the use of chemical controls. MSI is an example of how to develop positive working relationships among stakeholders to improve weed and land management. A new method of analyzing wool samples at the time of shearing has improved the segregation of wool samples by micron size. Researchers met with military personnel to discuss the potential for

the use of wool fibers that are 19 microns and finer.

There are no efficacious brucellosis vaccines for bison and current vaccines are only partially effective in livestock. Studies in cooperation with Texas A&M have produced new subunit and live brucellosis vaccines that may effectively protect bison and cattle against brucellosis. Formulation trials are underway to make these vaccines available to livestock producers and wildlife managers. Additional bison studies are evaluating antimicrobial proteins present in bison neutrophils and testing their activity against several pathogens. A better understanding of these proteins could lead to practical applications to controlling infectious diseases in bison and other wildlife while reducing concerns of cattle producers in areas near Yellowstone National Park.

Biobased Products and Processing

Situation: The revitalization of agriculture and rural communities in Montana is essential for the state's economic sustainability and competitiveness. The future of Montana's agricultural economy depends on maximizing net returns per crop acre or per animal unit, while using resources efficiently and adding value to raw agricultural commodities and processed foods. MSU initiatives in the development of sustainable energy alternatives provide opportunities for creating renewable biobased products from Montana crops.

Priorities: MSU's Biobased Institute provides an infrastructure that encourages collaborative programs addressing issues such as biobased products, value-added alternative crops, value-added meats, and food risk assessment. The objective of the Institute is to develop an innovative and responsive program to capture and enhance the developing agricultural opportunities of Montana and the Pacific Northwest/Northern High Plains regions and to build a biobased economy that provides in-state manufacturing, product development, job opportunities, rural development, and an opportunity to increase farm and ranch incomes. The Biobased Institute funds research projects that strive to increase the profitability of Montana agriculture, enhance the health of the human population, and reduce our reliance on non-renewable energy. A prime emphasis of our research is to add value to existing Montana products and to commercialize new products, while maximizing our limited resources and reducing reliance on commodity agriculture. The Institute currently supports 14 biobased research projects and has developed several high-value biobased products.

Input: Partnerships have been created among producers, the agricultural industry, MSU faculty, and other educational institutions in the region. These partnerships provide outreach activities related to biobased products and food science that are disseminated widely across the region. The Biobased Institute uses input from focus groups and meetings of stakeholders to identify strategies for marketing higher value agricultural commodities, consumer products, and alternative crops. MSU research provides the technology and biotechnology that improve plant and animal production systems while adding value and improving food security for our stakeholders.

Research Activities: The Biobased Institute funds cutting edge research that is innovative and responsive to the developing needs of the region by: (1) developing value-added end-use products with a competitive edge; (2) enhancing agricultural production approaches; (3) developing systems for food safety and agricultural security; (4) establishing biobased product and food science education and research; (6) enhancing partnerships across the region; and (7) conducting outreach activities related to biobased products and food science for producer, agribusiness, and others.

Research continues into developing alternative crops in Montana. The Biobased Institute has been instrumental in identifying potential oilseed crops suitable for production in Montana for use as culinary oils, biolubricants, omega-3 oils, feeds, and production of biodiesel and bioenergy products. Oilseeds (including *Camelina sativa*, canola, soybean, and safflower) are rapidly emerging as important Montana crops for production of oils. Several products are being produced and marketed by private industry or grower cooperatives, including PrOatina gluten-free oats to the celiac community and beta-glucan barley to the nutraceutical industry. The increased demand for high-protein, gluten-free oatmeal is being met by the establishment of a processing facility in Montana. Fenugreek, an annual legume, shows promise as a nutraceutical feed for geriatric and athletic horses. Teff is being developed as gluten-free flour. Canola, chickpea, fenugreek, camelina, and assorted herbs have been evaluated for their potential in emerging value-added markets. Technology transfer collaborative relationships have been developed with the Montana Ag Innovation Center, MSU TechRanch, and MSU TechLink. Collaborators have expertise in incubating new and existing products and businesses.

Additional initiatives will provide new insights into food safety and risk assessment, including the use of vegetable oils as feedstock for fuel cells, the development of new wheat varieties, non-corrosive biobased de-icers, and the optimization of ethanol production from various feedstocks. Continued genetic research into the expression of undesirable characteristics in grains will help ensure that the grains will maintain their commanding presence in the Asian market. The use of transgenic crops continues to present questions regarding the potential risk to human health and the environment. Computer modeling and data from greenhouse and field experiments will help in risk assessments to estimate what hazards may be associated with transgenic crops.

Integrated Pest Management (IPM)

Situation: Weeds, diseases, and insects continually challenge Montana producers who are often producing crops under less than ideal conditions. Difficult-to-control pests challenge producers and researchers to evaluate new IPM methodologies in order to maintain a competitive position in U.S. and world markets. The increase in public concern about food quality, cost,

natural resource biodiversity, and sustainability of the quality of soil, air, and water is mandating less reliance on traditional pesticides and research into more environmentally friendly systems, including biological controls. Foreign trade partners want decreased pesticide residues in the wheat and barley commodities that are imported into their countries.

Priorities: IPM programs in Montana seek to optimize grower profitability and natural resource sustainability through the development, selection, and implementation of economically sound and environmentally acceptable pest management strategies. MSU is continuing research into less chemically dependent systems and is addressing the economic feasibility and environmental impact of biological controls. The understanding of crop rotation systems, crop production methods, and water management issues is a priority in the production of abundant high quality crops. Unraveling complex ecological relationships is central to understanding pest management systems, implementing biological controls, and exploring a multitude of science-based options.

Inputs: The source of funds contributing to the research conducted by MAES faculty include, but are not limited to: Montana crop and animal agricultural groups, Montana Ag Business Association, Montana Department of Agriculture, Montana Fertilizer Advisory Committee, Montana Grain Elevator Association, Montana Noxious Weed Trust Fund, Montana Wheat and Barley Committee, other states, private donations, private industry, Western Sustainable Agricultural Program, and USDA. Stakeholder input is collected in county and reservation sponsored input meetings, listening sessions during pesticide applicator education programs, and a Farm Bill Forum. The development of more environmentally friendly chemical and non-chemical alternatives requires ongoing interaction with chemical and biological pest control product manufacturers, state and federal agencies, and with researchers in other states.

Research Activities: Montana's stakeholders need new and improved methods for controlling insects, weeds, and diseases. Comprehensive programs have been established at MSU to investigate low impact control options and promote sustainable practices that will help stakeholders be more productive. MSU's entomology collection is the largest holding of insects in the Northern Great Plains. Numerous visitors, faculty, and researchers make use of this resource for their research and increased understanding of native and exotic species of insects and other arthropods.

The production of adequate and quality hay is critical to the success of livestock producers in Montana. Managing forage insects, including lygus bugs, aphids, alfalfa weevil and clover root curculio, while protecting beneficial insects, especially honeybees and leafcutter bees, is a difficult challenge. Determining factors that impact beneficial insects and finding options to reduce yield damaging insects are priorities for this crop. Alfalfa hay management programs have been initiated to look at traditional use of chemical control methods, non-chemical control methods, biological controls, and cultural management options. Research into forages includes the examination of pest and natural enemy complexes and their interaction. Our work over the past several years has provided important groundwork for this research including the development of a large reference collection of pollinators, including bee and wasp species, from several Montana locations. We have made substantial progress creating pollen reference collections for several of the sites documenting the local flowering plants at sites where we will be conducting diversity and behavioral studies.

The wheat stem sawfly is a severe pest of wheat in the northern Great Plains; current management is based primarily on the adoption of solid-stem varieties that offer only partial resistance to the pest. MSU research seeks to examine the integration of natural enemies, pathogens, and chemicals for management of the pest and to develop new sources of host plant resistance.

Soil-borne plant pathogens cause about 90% of the major diseases of the principle crops in the United States with revenue losses in excess of \$4 billion/year. MSU projects identify effective and economical biological controls for diseases with the intent that the information will help growers control plant diseases using methods low in toxicity to humans and the environment. The management of diseases in potatoes and sugar beets is becoming increasingly difficult according to growers who participated in MSU sponsored meetings. *Muscodor albus* seed treatments show promise as an alternative to chemical pesticides for control of several *Rhizoctonia* and scab diseases of potatoes. Placement of *M. albus* mixtures with other synthetic mixtures of the volatile antibiotics produced by these endophytic fungi exerted a positive effect in controlling fungal and nematode caused diseases. A new potato fungicide management program was developed by MSU research and continues to be used for control of *Rhizoctonia* black scurf in potatoes. No-till cereal production combined with a conversion from wheat-fallow to annual cropping has lead to more intensive disease pressure for Montana producers. The use of anti-fungal proteins incorporated into transgenic plants is another promising approach to limiting fungal diseases of cereals. The purpose of one project is to address cereal disease problems that are exacerbated by the adoption of no-till. *Bacillus mycoides* isolate BacJ has induced resistance in a wide range of crop plants (both in the greenhouse and in the field) with disease control on sugar beet, cantaloupe, cucumber, and tomato being equal to commercial products.

Herbicide use in Montana's grain production systems represents the single largest use of pesticides in the state. Improving wheat competitiveness and herbicide tolerance with consideration given to seed quality and seedling vigor are priorities among researchers. In discussions about problem weeds in Montana, stakeholders most often mention spotted knapweed, Canada thistle, and kochia as their most severe problems, especially in rangelands and pasture. Wild oats continue to be the predominant weed for small grains producers. In order to continue to serve the stakeholders with improved recommendations

and non-chemical alternatives, several research projects are underway to evaluate innovative control measures.

Spotted knapweed is a biennial or short-lived perennial that commonly grows to three to four feet tall and continues to spread throughout pastures and rangeland. Management of knapweed with biocontrols will increase rangeland productivity and plant diversity, while enhancing Montana's economic return from agriculture while improving wildlife habitat. One MSU project looks at managing spotted knapweed through the controlled grazing by sheep; other exotic weeds are controlled by the introduction of natural insect enemies. For biological controls to be effective, evaluation of their long-term impacts on ecological communities must be made prior to their release. Natural enemy efficacy studies will observe the ecological and physiological basis for insect-host interactions. Characterizing the ecological communities in which natural enemies survive is fundamental to developing and understanding the influence that habitat and environmental factors have on natural enemy densities. Also, the project determines the environmental safety of exotic natural enemy candidates and plant pathogens prior to their release into the environment. Improving the understanding of soil resource use by invasive species may allow control efforts to focus on sites or years when soil conditions may favor invasion, or conversely, when plants may be more vulnerable to control measures. The identification and testing of various arthropods for the biological control of hoary cress, field bindweed, rush skeletonweed, Russian knapweed, tansy ragwort, and invasive hawkweeds continued.

MSU continues to conduct herbicide screening trials to assess the effectiveness of new and existing products for weed control in small grains, sugar beets, and potatoes, under a range of environmental and crop conditions representative of Montana agriculture. Herbicides are being evaluated at outlying research stations for use in the state's developing crops, including mint, camelina, dry beans, dry peas, and canola. MSU research into the mechanisms of weed resistance helps manufacturers of crop protection products develop herbicides that target specific biochemical processes within the plant.

Millions of dollars are spent annually on wild oat control in the Northern Great Plains. Wild oats are being used as a model weed species to determine if dormancy or other maternal plant or seed characteristics are associated with the ability of non-germinated wild oat seeds to persist in the soil and resist decay. The long-term goal of this research is to improve weed management by developing a basic understanding of factors that influence weed seed bank decline and identifying causes of weed seed mortality.

MSU's Seed laboratory provides testing services for State and Federal agencies, private seed companies, farmers and ranchers to provide vital information on seed quality. Standardized testing protocols are being established for Camelinasativa which has a large potential impact as a crop and a valuable asset in crop rotations.

Plant Breeding, Genetics, and Genomics

Situation: MSU is a recognized international leader in the development of new cultivars of small grains that are sought by buyers around the globe. Researchers evaluate germplasm and identify traits that produce wheat and barley cultivars that meet increasing world demands for quality, while maintaining yields for producers. An aggressive plant breeding program ensures development of higher yielding, disease and insectresistant wheat and barley cultivars. Additional work in the development of alternative crops continues to produce new market opportunities for Montana producers.

Priorities: 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 of important crops to remain competitive in the world market place. Primary breeding objectives include increasing yield potential, improving winter hardiness, wheat stem sawfly resistance, imidazolinone herbicide tolerance, and enhanced dual-purpose end-use quality. MSU's intensive genomic research will help Montana producers stay competitive and will provide improved cultivars adapted to Montana climatic conditions and cropping systems. Increased understanding of the molecular biology and biochemistry of cereal grains will lead to the development of products more suited to the requirements of competitive world markets.

Input: Recommendations and priorities are established by foreign trade teams, international trade missions, faculty, staff, and students. Farmers cooperate by providing dryland and irrigated fields for variety trials and by providing associated inputs. Research grants and proposals are received from the Montana Wheat and Barley Committee. Through stakeholder input, we are routinely applying for PVP title V status on all released wheat and barley varieties, which in turn increases revenues for research.

Research Activities: A major effort is underway to characterize and evaluate wheat and barley germplasm and to increase the utilization of world germplasm collections. 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 \$5-\$6 million in revenue per year to the Montana economy. A recently released solid stem winter wheat cultivar, Genou, has improved yield potential, especially in wheat stem sawfly-infested areas of Montana. Sawfly-resistant wheat cultivars can prevent crop-yield losses of from 15 to 90%. Research results are distributed to farmers, colleagues, and stakeholders through technical and non-technical publications, through the release of germplasm, and through new genomics tools and techniques.

The development and distribution of improved barley varieties is a priority of the barley breeding program. MSU recently released four new feed, forage, and malt barley varieties for Montana's production environments that will provide added-value to growers throughout the Northern Plains. The replacement of older barley varieties with new ones (Haxby, Hays, Charles, Craft,

and Eslick) should generate a yield improvement of about 15% with a net of about \$45 million per year in added revenue to dryland barley growers; three malting barley varieties (Craft, Geraldine, and Hockett) should result in about \$80 million in added revenue. Programs use quality field research technologies, extensive on-station and on-farm trials, and state-of-the-art genomics tools to develop well-adapted, high yielding, improved quality barley varieties. Barley research will continue to focus on the development of high-quality drought tolerant lines for the malting, feed, and ethanol industries. Varieties with improved feed quality could provide sustainable seed and grain markets for regional grain producers and marketing advantages to regional beef producers. Research trials found few differences in feedlot performance between steers fed finishing diets based on corn or Valier barley; this knowledge translates into increased markets for barley producers and lower average costs of gain for local cattle feeders. Our understanding of the genetic control of traits like winter hardiness, feed quality, malting quality, and drought tolerance has been developed and extended through genetic diversity experiments.

Montana crop producers want improved hard red and hard white winter wheat cultivars that are adapted to Montana conditions and suitable for both domestic and export markets. Successful genetic research will increase the competitiveness of Montana wheat producers through improved winter wheat cultivars with enhanced yield potential, pest resistance, and desirable end-use qualities. The Asian noodle market is an important business opportunity for Montana growers. The quality of noodles made from different wheat samples is evaluated on entries from the MSU and intrastate nurseries. Polyphenol oxidases (PPOs) have been implicated in wheat product quality problems, including the undesirable darkening of Asian noodles. A long-term goal of this research is the development of low-PPO germplasm with higher commercial value. MSU research is examining the degree to which puroindoline proteins control wheat grain hardness and cereal quality and what alterations can be made to generate desired milling and end-product quality. Further research will address the effects that modifying the starch biosynthetic pathway has upon grain hardness, milling quality, yield, and end-product quality. In addition to improved cultivar characteristics, researchers are evaluating more efficient screening, selection and breeding strategies to maximize efficiency and genetic progress in breeding programs.

MSU research provides methods to analyze all lines of wheat to detect novel gene expression related to postharvest resistance, which could lead to new strategies for protection in storage from insects, especially for organic growers. Postharvest resistance to insects has not been a breeding program objective, but could be a secondary objective provided that milling, baking, noodle quality, and other important properties are not affected.

Hard red spring wheat is the leading crop in Montana. Farmers need new and better cultivars with excellent qualities to ensure that Montana wheat retains or increases its share of Asian and domestic markets. Research objectives include developing new spring wheat varieties for Montana producers and contributing to the science of wheat breeding and genetics. Bread making characteristics, especially dough strength and extensibility, are considered when evaluating spring wheat cultivars. Continued productivity of our breeding program will improve our understanding of the genetics of key traits and allow the development of new selection tools. The broader impacts of the work 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.

Alfalfa is the most important forage legume grown in Montana. MSU is seeking to develop multiple pest-resistant dryland cultivars with good agronomic traits for Montana. In addition to alfalfa projects, efforts have been made to develop new grass cultivars suitable for Montana. MSU research, often in cooperation with NRCS, has resulted in the release of new grass cultivars and a new sainfoin cultivar.

Whitebark pine forests are in serious decline due to blister rust and mountain pine beetles; their decline will likely affect grizzly bear populations that depend on the pine nuts for food in YNP. Mycorrhizal fungi are crucial to the sustainability of these forests; yet we know nothing of the fungi associated with this tree species. The objective of this research is to develop systems to inoculate nursery grown stock with appropriate native fungi that will prevent further decline and begin to reestablish forested areas.

Plant viruses are used as protein cage architectures for the synthesis of nanomaterials. Projects are in place to use plant viruses as biotemplates for the fabrication of nanomaterials with applications in agriculture, medicine, and material sciences. The advances made have demonstrated that it is possible to modify plant viruses and other protein cage architectures to impart novel functions. We have made significant advancements in demonstrating the practical applications of this science in drug delivery, Magnetic Resonance Imaging (MRI), and as a new method for hydrogen production. These discoveries significantly contribute to Montana's and the nation's efforts in nanotechnology.

Plant photoreceptors and the light responses they control are critical to growth and development of crop and non-crop species throughout the world. Developing an understanding of how the phytochrome photoreceptors work is a critical part of the search for new and effective ways to sustain and improve agronomic performance.

By determining the fate of nitrogen in plants from anthesis to plant death, we expect to improve our understanding of the cellular and molecular details of nitrogen remobilization, thus closing an important knowledge gap in modern plant biology. MSU research is working to identify the genes involved in control of inflorescence development to provide new approaches to breeding practices or transgenic manipulation. Plant research in high CO₂ environments in YNP may offer a window into the

future regarding the nature of plant growth and survival in a high-CO₂ world.

Sustainable Agriculture

Situation: Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. Researching new crops and finding new markets for existing crops are potential ways to enhance Montana's growth in sustainable agriculture. Farmers and ranchers in Montana have historically practiced sustainable activities due to the marginal opportunities for success in a semi-arid climate. A basic principle of sustainable agriculture is to investigate current agricultural practices and find economically feasible and environmentally friendly alternatives to current agricultural practices. These include optimizing the use of chemicals for pest control, using alternative tillage systems, and increasing crop diversity. With the continuing rise in fuel prices, farming practices that reduce dependence on fuel will add to the profitability of the enterprise. This factor alone provides incentives to farmers to investigate sustainable agricultural methods. Increases in ethanol production from corn has put upward price pressure on small grains and also increased interest in using small grains for ethanol production. Camelina and safflower have demonstrated high overall adaptation to dryland conditions that often prevail in much of Montana. The shift to more efficient and profitable specialty crops will continue to generate major interest in the future. The use of the Internet for information dissemination has become an increasingly valuable method to provide stakeholders with materials to assist in their decision-making. As technology advances and producers begin to rely more on computer-aided information, the role of MSU research and outreach will continue to increase in their importance and impact.

Priorities: Research conducted in sustainable agricultural projects support our priority to develop competitive, sustainable, and viable plant and animal systems for Montanans. Increasing crop diversity with the use of oilseeds like camelina will improve crop agronomics and will improve the economic well-being of dryland agricultural producers in the Northern Plains. In order to decrease Montana's primary dependence on small grains and forage crops, research is being conducted on the feasibility of growing a variety of crops including pulse crops (pea, lentil, chickpea, and soybean), herbs, mustard, safflower, sunflower, canola, turf grass, and specialty grains.

Input: Evaluation surveys of farm conferences in Montana highlight strong producer interest in improving crop diversity. Information and financial assistance come from alternative energy groups, conservation tillage equipment companies, crop protection companies, fertilizer advisory committees, Montana Wheat and Barley Committee, Organic Certification Association of Montana, and State agricultural advisory committees. While meetings, interviews, and focus groups will continue to be used to gather information from stakeholders, the increasing use of computer modeling and surveys will add to data being collected.

Research Activities: 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 policy. Surveys at Montana farm conferences indicated a strong interest in diversified crop rotations. We are presently researching alternative pest control practices, including biological pest control for forages, potatoes, small grains, and sugar beets, which are of utmost interest to stakeholders. Winter and spring peas, canola, corn, lentil, mustard, sunflower, triticale, and chickpea are included in long-term rotation studies. Onions are also being investigated as an alternate crop. Pulse crop production continued to increase with 431,000 acres planted in 2006. This represents an important new source of income for Montana farmers and provides opportunities for increasing crop diversity. Research into new crops such as dwarf and slow-growing lawn grasses, native ornamental flowers, essential oils, and crops for natural rubber production and bioenergy are examples of research that will provide new opportunities for growers and their communities. Timothy has been identified as a promising gluten-free cereal with flavor properties similar to wheat. Several germplasm accessions of timothy have been tested for suitability as turf grass. Fenugreek has been evaluated for acceptance by the equine industry and for its use in human nutrition. Over 220 fenugreek germplasm accessions have been evaluated for their production potential in Montana. MSU is evaluating disease resistance in safflower, which is an alternative crop for wheat producers in Montana. New safflower varieties with improved nutritional characteristics are being evaluated. Nutrasaff, a high linoleic safflower with high seed oil content, high meal protein and reduced meal fiber is available as a high-end nutritional supplement for livestock, birds, and pets.

Prescribed livestock browsing is a promising tool to better enable range and livestock managers to suppress conifers that have encroached upon large acreages of Montana rangeland. Livestock grazing practices are receiving increasing attention because of their perceived negative impacts on soils, biodiversity, and water quality. Understanding the requirements of cattle during winter months will help producers plan feeding schedules and adjust protection requirements from severe weather conditions.

Most land managers agree that the spread of non-native invasive plants is a serious environmental threat to western wild lands. Large blocks of rangeland in the West are infested with noxious weeds (e.g., leafy spurge, spotted knapweed) to the extent that the land will not support grazing by traditional livestock and wildlife. Sheep grazing provides the only economically feasible and ecologically sound tool to restore landscapes heavily infested with noxious weeds to a level that will support traditional livestock and wildlife grazing.

By the latter half of the 21st century, climate change could jeopardize agriculture, forestry, crop production, and other industries dependent on the natural environment. Studies under several crop rotation systems continue to address questions on the contribution to global warming of agricultural nitrous oxide (N₂O). N₂O is estimated to be over 300 times greater than carbon dioxide in its atmospheric warming potential. Studies are in place to validate or refute methodology for estimating N₂O emissions in the Northern Great Plains. Scientific interest in the effects of increasing atmospheric CO₂ on plants has motivated us to better understand plant photosynthetic physiology and plant community structure in the high-CO₂ environments of YNP. Several projects have looked at flora growing in or near the hot springs in YNP. Understanding the mechanisms of growth of these native plants in geothermally-modified soils will help researchers gain insight into how climate change may impact agricultural production. Additional projects are investigating the potential for soil carbon sequestration in rangelands; information produced by this research will improve the ability of public decision makers to formulate policies regarding climate change and greenhouse gas mitigation.

Our stakeholders charge us to improve animal health and to improve food safety and quality through sustainable practices. Two major initiatives address the needs of Montana livestock producers: the Montana Sheep Institute (MSI) and the Montana Beef Network (MBN). The objective of the MSI is to develop and implement nontraditional strategies that will increase the competitiveness of Montana lamb and wool in world markets. Two objectives focus efforts on the reduction of lamb mortality and on sheep grazing as a tool in natural resource management. Research in the feed and supplements fed to lambs is being conducted to produce lambs with higher levels of unsaturated fatty acids in the lean tissue. This nutritional alteration could provide significant marketing opportunities for sheep producers. Wool research is designed to develop, evaluate, and implement tools and technology for improving the quality, marketing efficiency, and international competitiveness of U.S. wool. This project will evaluate and develop tools and technology for improving the quality, marketing efficiency, and international competitiveness of U.S. wool.

The MBN was established to return additional revenue to cattle producers and meet consumer needs in Montana and the nation. Domestic and international consumers are demanding more information about the beef they purchase, including the age and source of the animal and the health, nutrition, and handling management. An integrated network is in place to ensure that a quality and consistent beef product is being produced and to enable the tracking of calves from Montana ranches to feedlots and packing plants in other states. The project is designed to assist producers to meet these demands through education of best management practices, assistance with carcass data collection, programs to help producers take advantage of marketing, and through research to address regionally specific issues affecting beef production. Tracking will provide both source and process verification for easy trace-back in case there is a disease outbreak. With the MBN in place, it will be relatively easy for Montana producers to adapt to mandatory country-of-origin labeling (COOL) and national animal identification programs.

Water Quality and Use

Situation: Montana is a headwater's state (Missouri River, and tributaries of the Snake, Yellowstone, and Columbia Rivers) with pristine waters that have scenic value, agricultural and manufacturing applications, and provide recreational opportunities for Montanans and visiting tourists. A number of diverse ecological systems in Montana provide research opportunities for scientists to study interactions under the climatic conditions and land use practices inherent to the state.

As a semi-arid state, most crops are dependent on irrigation from streams and groundwater systems. Stream flow, groundwater, surface water, fisheries, and wildlife are heavily dependent on winter snowpack for the continuing adequacy of water supplies. Irrigated agriculture is the largest user of freshwater in Montana with 1.7 million acres under irrigation using approximately 8.9 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: Research information on water utilization and management in the Northern Rockies is very limited. Finding crops that require less water per acre and will grow in our short growing season requires innovative solutions. This is being partially accomplished through MSU's extensive crop breeding programs, water management research, the introduction of new drought tolerant crops, and other conservation practices. Evaluating watersheds to determine the best integrated approaches for raising crops, grazing livestock, and other uses will help protect riparian areas and improve our state's fisheries and wildlife habitat.

Input: Input comes from meetings with conservation and wildlife groups, Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), Montana Department of Agriculture, Montana Fish, Wildlife and Parks, NASA, NRCS, State of Montana, USFS, USGS, and other organizations interested in water quantity and quality issues. Extensive water monitoring across Montana has helped researchers develop predictive models that help direct future research.

Research Activities: Soil water is a primary limiting factor for plant growth in semiarid and arid regions like Montana. In order to provide sustainability to Montana producers and urban dwellers, several programs are in place to evaluate, monitor, and provide cropping and irrigation recommendations to agricultural and urban stakeholders.

An understanding of the relationship between water runoff and land features is critical to developing better utilization of limited water resources. This knowledge aids not only crop and livestock producers, but those involved in city and county planning departments who must establish long-range plans for housing development, waste management, and water usage.

Mapping soil water content for site-specific management of farm fields is commonly achieved through grid soil sampling. A new frequency domain approach to measure the static dielectric constant will facilitate measurements with very small probes. The results will lead to tools with applications that lower costs to producers and rangeland managers and improve monitoring efficiency. A new approach to current hydrologic modeling will enable science-based decisions to be made in the management of irrigation practices in the Western U.S.

Secondary education science teachers find little time to present more than just basic information on water use and management in their curriculum. The development of an experiential course in the science of water quality for secondary education students provides a way to introduce children to the basics of natural resource management. The program provides secondary science teachers with comprehensive water quality education, provides activities that are transferable to secondary science students, and provides rural, place-bound and distant students equal access to water quality education. This program will help our youth (our future community leaders) in their understanding of agricultural water requirements and the role of water in landscapes.

In order to serve a need of urban and suburban homeowners, MSU has undertaken a project to evaluate native plants and grasses in the landscape. Most turf grasses, particularly Kentucky bluegrass, require large amounts of water to maintain their appearance and growth. There is an increased interest in "native" landscaping; however native trees, shrubs, and perennial forbs planted with non-native grasses do not fit the palette for a totally native landscape. We have completed the second season of research on the water requirements of native grass species; data suggest that some species can withstand up to a 60% reduction from the current water recommendations and still maintain a quality lawn. This program will reach those stakeholders who typically are not major recipients of MAES research.

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

Year	Extension		Research	
	1862	1890	1862	1890
2009	0.0	0.0	300.0	0.0
2010	0.0	0.0	300.0	0.0
2011	0.0	0.0	300.0	0.0
2012	0.0	0.0	300.0	0.0
2013	0.0	0.0	300.0	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

Hatch Projects are subject to a rigorous review at the department level, followed by a peer review, with final approval at the Director's level. The MAES Director's Office has oversight of this review process. The peer review committee, selected by the Director after consultation with College of Agriculture 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. Seminars are presented to the review committee and to interested stakeholders, including faculty, staff, students, and constituents. New projects are required to be proposed for a 3-year period, while ongoing projects that receive a favorable merit review can be written for a 5-year period. No Agricultural Experiment Station funds are allocated outside of the College of Agriculture, consequently external expert review occurs with Montana State University-Bozeman faculty external to the College of Agriculture, as a requirement of the review process. The seminars are announced on the web, ensuring broader attendance and input potential. Reviewers are requested to provide written recommendations on the following items: 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 responses are presented to the PI during a subsequent

meeting with the MAES administrator and department head. Projects that do not meet expectations will not be approved and action upon them will be deferred until all of the key elements listed above have been satisfactorily met. Ultimately, Director-approved projects are submitted to USDA CSREES for final approval.

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 the 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 very small overall population and an even smaller percentage 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 for short periods of time, typically in the summer.

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

In order to continue receiving State support that is five times the amount of federal support (Hatch, Multistate and Animal Health), our research must demonstrate actual or potential economic impact to Montana's economy and solve problems at the local-to-state level. In simple terms, this could be the result of increased crop yields or through advances in crop or animal production efficiency. Deriving additional income from value-added products and new enterprises helps to diversify risk and create additional opportunities for income. As a result of the new knowledge created through research activities, there potentially can be policy changes that impact agency management decisions. For example, 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 to identify their needs in those locations. In addition, if a new vaccine is developed for management of brucellosis in bison, the National Park Service would have new options that could lead to more socially acceptable management of bison in Yellowstone National Park.

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

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. In addition, Montana stakeholders provide the impetus for continued and growing financial support through MAES programmatic emphasis important to the number one basic industry, agriculture.

IV. Stakeholder Input

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

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

Brief explanation.

The Montana Agricultural Experiment Station (MAES) and College of Agriculture (COA) obtain stakeholder input on research priorities and programs. Stakeholder committees have been formed that include the College Development Board, Precision Ag Research Association (PARA), sustainable agriculture focus group, MAES Advisory Council, Ag Coalition and other state and local groups. PARA is external to MAES, charges its own dues, and conducts quarterly meetings throughout Montana with members and selected professionals. MAES scientists routinely participate with this group and NRCS to provide training and expertise in GPS, GIS and remote sensing with geospatial applications. PARA and MSU have secured a number of USDA, NASA, and industry grants to initiate collaborative projects on their property as part of the MSU originated "Learning Groups" concept. The Ag Coalition consists of representation from the Agricultural Business Association, Beef Council, Department of Agriculture, Farm Bureau Federation, Montana Stockgrowers, Montana Farmers Union, Montana Water Users, Montana Wool Growers, Seed Growers, and the Seed Trade. It meets every six months with the Dean and Director to review program priorities, new initiatives, fundraising efforts, and legislative activities. Meetings were advertised via news releases, newsletters, individual letters, and announcements at group meetings. Extension agents were instructed to use county profile information to make sure that the people invited to the sessions would reflect the diversity of the area. MAES responds to stakeholder inputs by considering their proposals at research planning meetings with scientists, advisory groups and administrators. Stakeholder input has been solicited in the strategic planning process and continues throughout as programs are developed, implemented, and changed as dollars are allocated and reallocated. Surveys have been used to collect input from representative groups of stakeholders in Montana. Questions in the survey were based upon the areas of emphasis in the strategic plans of the College of Agriculture/Agricultural Experiment Station and the Extension Service.

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

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

Brief explanation.

Each of the seven agricultural research centers has a local advisory group that meets 2–3 times per year. In addition, a State Advisory Committee meets three times per year to discuss program focus and direction, legislative priorities and productivity/impact. All of these meetings are open to the public. Administrators and faculty in the COA serve on agricultural association committees that direct and fund research activities that have multiple meetings and communications throughout the year.

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

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

Brief explanation

Through our direct participation with agricultural stakeholder groups, broad participation in committees, and directed meetings, the MAES engages in listening to and considering a defined problem or question that can be addressed through our research programs. The Director targets selective meetings with non-traditional groups. Montana has an open meeting law, so

all meetings are open to the public and must have a published agenda.

3. A statement of how the input will be considered

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

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. The COA and MAES are the leaders in this regard. We are the primary conduit in connection and delivery of education and new knowledge in agricultural activities throughout rural Montana.

V. Planned Program Table of Content

S. NO.	PROGRAM NAME
1	Water Quality and Use
2	Integrated Pest Management
3	Sustainable Agriculture
4	Biobased Products and Processing
5	Plant Breeding, Genetics and Genomics
6	Animal Health
7	Agronomic and Forage Crops

V(A). Planned Program (Summary)**Program #1****1. Name of the Planned Program**

Water Quality and Use

2. Brief summary about Planned Program

Montana is a headwater's state (Missouri River, and tributaries of the Snake, Yellowstone, and Columbia Rivers) with pristine waters that have scenic value, agricultural and manufacturing applications, and provide recreational opportunities for Montanans and visiting tourists. Montana is in a unique position to understand how land management practices impact ecosystems. Surface landscape practices, including agriculture, energy development, mining, and urbanization can severely impact both water quality and quantity. Evaluating watersheds to determine the best approach for raising crops, grazing livestock, and other uses will help protect riparian areas and improve our state's fisheries and wildlife habitat. Everyone in the state is impacted by water quality and quantity, whether it is managing reserves for agricultural production, for recreational use, or for daily consumption.

Research Activities: In order to provide sustainability to Montana producers and urban dwellers, several programs are in place to evaluate, monitor, and provide cropping and irrigation recommendations to agricultural and urban stakeholders. Water quality and use projects at MSU tend to be long-term with little change from year to year. Research is continuing to better understand the relationship between alpine headwaters and valley bottom wetland systems to control streamflow quantity, runoff timing, and water quality. An understanding of the relationship between water runoff and land features is critical to developing better utilization of limited water resources. This knowledge aids not only crop and livestock producers, but those involved in city and county planning departments who must establish long-range plans for housing development, waste management, and water usage. Mapping soil water content for site-specific management of farm fields is commonly achieved through grid soil sampling. A new frequency domain approach to measure the static dielectric constant will facilitate measurements with very small probes. When this research is complete, investigators will be much closer to the routine estimation of specific surface area in soils for environmental and agricultural monitoring.

MSU is developing and delivering an on-line, experiential course in the science of water quality for secondary science teachers who may be struggling with other time commitments. The program will provide secondary science teachers with comprehensive water quality education; provide activities that are transferable to secondary science students, and provide rural, place-bound and distant students equal access to experiential water quality education. There is an increased interest in "native" landscaping; however native trees, shrubs, and perennial forbs planted with non-native grasses do not fit the palette for a totally native landscape. We are seeking to learn which native and adapted grasses are suitable for turfgrass applications, their water and mowing requirements, their potential to form a sod, and their ability to establish and/or restore a landscape. This program will reach those stakeholders who typically do not see results from major MSU research and outreach projects.

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
111	Conservation and Efficient Use of Water			30%	
112	Watershed Protection and Management			30%	
610	Domestic Policy Analysis			10%	
903	Communication, Education, and Information Delivery			30%	
	Total			100%	

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

1. Situation and priorities

Montana is a headwater’s state with pristine waters that have scenic value, agricultural and industrial applications, and provide recreation for Montanans and visiting tourists. Stream flow, ground and surface water hydrology, fisheries and wildlife are heavily dependent on snow pack for the continuing adequacy of water supplies. A number of diverse ecological systems either border Montana or are located within the state. These systems provide opportunities for extensive research into how they behave under the climatic conditions and land use practices in Montana. As a semi-arid region, most irrigated crops are dependent on water either from streams or underground sources. Farmers are especially dependent on water reserves and stream flow to produce crops requiring greater water use. All Montanans are affected by decisions made to regulate water usage in the state. Research information on water utilization and management in the Northern Rockies is very limited. Finding crops that require less water per acre and will grow in our short growing season requires innovative solutions. This is being partially accomplished through breeding programs, water management research, and the introduction of new drought tolerant crops. Research investigates alternative cropping systems and identifies ways to measure and predict water availability. Priorities include:

- Continue crop breeding investigations and changes in management practices
- Evaluate watersheds to determine the best approach for raising crops, grazing livestock and other uses to help protect riparian areas and improve the state’s fisheries and wildlife habitat
- Finding crops that require less water per acre and that will grow in the shortened growing season
- Protect watersheds to ensure that water supplies are not interrupted due to inappropriate management

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 the studies

•Conservation and wildlife groups, producers, and grain and livestock associations will continue to provide input into priorities and activities

•Drought may impact research results

•Fulltime 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

•Provide secondary education students with quality instruction by trained teachers in the understanding and protection of our water resources

•Provide soil water mapping tools with applications that lower costs of water and improve monitoring efficiency

•Provide stakeholders with a better understanding of the relationship between water runoff, land features, and land

use practices

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
2009	0.0	0.0	20.0	0.0
2010	0.0	0.0	20.0	0.0
2011	0.0	0.0	20.0	0.0
2012	0.0	0.0	20.0	0.0
2013	0.0	0.0	20.0	0.0

V(F). Planned Program (Activity)

1. Activity for the Program

- A new approach for mapping soil water content for site-specific measure will allow measurements with very small probes
- An on-line, experiential course in the science of water quality for secondary science teachers who may be struggling with other time commitments is developed
- Better utilization of limited water resources in Montana
- Research results will be communicated in meetings with key organizations who impact decisions on water quality and quantity in Montana
- Results from research will help to mitigate potential economic losses or disasters from inadequate or excessive water related events

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"> ● One-on-One Intervention ● Workshop ● Education Class ● Demonstrations 	<ul style="list-style-type: none"> ● Web sites ● Newsletters

3. Description of targeted audience

- Organizations to be contacted include U.S. Geological Survey (USGS), National Resources Conservation Service (NRCS), the Montana Department of Natural Resources and Conservation (DNRC), irrigation districts, conservation districts and downstream and instream users
- Secondary education science teachers

V(G). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons(contacts) to be reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
2009	350	400	0	0
2010	400	400	0	0
2011	450	400	0	0
2012	500	400	0	0
2013	500	400	0	0

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

Expected Patent Applications

2009 :0 2010 :0 2011 :0 2012 :0 2013 :0

3. Expected Peer Review Publications

Year	Research Target	Extension Target	Total
2009	5	0	5
2010	5	0	5
2011	5	0	5
2012	5	0	5
2013	5	0	5

V(H). State Defined Outputs

1. Output Target

- Number of research citations.

2009 :12 2010 :14 2011 :14 2012 :16 2013 :16

- Successful external grants

2009 :2 2010 :2 2011 :1 2012 :2 2013 :2

V(I). State Defined Outcome

O. No	Outcome Name
1	Number of devices and models created for measuring the transport and fate of compounds.
2	Improved management systems for water quality and quantity.
3	Educational programs that address water resource use.
4	Number of landscape scale datasets created.
5	Number of improved prediction capacity models for snowpack/runoff into rivers and for instream flow.
6	Number of land and water use policies and practices developed by providing a scientific basis.

Outcome #1

1. Outcome Target

Number of devices and models created for measuring the transport and fate of compounds.

2. Outcome Type : Change in Knowledge Outcome Measure

2009 0 2010 : 2 2011 : 0 2012 2 2013 : 2

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 111 - Conservation and Efficient Use of Water
- 112 - Watershed Protection and Management

Outcome #2

1. Outcome Target

Improved management systems for water quality and quantity.

2. Outcome Type : Change in Action Outcome Measure

2009 0 2010 : 1 2011 : 1 2012 0 2013 : 0

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 111 - Conservation and Efficient Use of Water
- 112 - Watershed Protection and Management

Outcome #3

1. Outcome Target

Educational programs that address water resource use.

2. Outcome Type : Change in Condition Outcome Measure

2009 2 2010 : 2 2011 : 2 2012 2 2013 : 2

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 111 - Conservation and Efficient Use of Water
- 112 - Watershed Protection and Management
- 903 - Communication, Education, and Information Delivery

Outcome #4

1. Outcome Target

Number of landscape scale datasets created.

2. Outcome Type : Change in Knowledge Outcome Measure

2009 : 0 **2010 :** 2 **2011 :** 0 **2012 :** 2 **2013 :** 2

3. Associated Institute Type(s)

- 1862 Research

4. Associated Knowledge Area(s)

- 111 - Conservation and Efficient Use of Water
- 112 - Watershed Protection and Management

Outcome #5

1. Outcome Target

Number of improved prediction capacity models for snowpack/runoff into rivers and for instream flow.

2. Outcome Type : Change in Action Outcome Measure

2009 : 0 **2010 :** 1 **2011 :** 1 **2012 :** 1 **2013 :** 1

3. Associated Institute Type(s)

- 1862 Research

4. Associated Knowledge Area(s)

- 111 - Conservation and Efficient Use of Water
- 112 - Watershed Protection and Management

Outcome #6

1. Outcome Target

Number of land and water use policies and practices developed by providing a scientific basis.

2. Outcome Type : Change in Condition Outcome Measure

2009 : 2 **2010 :** 2 **2011 :** 2 **2012 :** 2 **2013 :** 2

3. Associated Institute Type(s)

- 1862 Research

4. Associated Knowledge Area(s)

- 111 - Conservation and Efficient Use of Water
- 112 - Watershed Protection and Management
- 610 - Domestic Policy Analysis

V(J). Planned Program (External Factors)

1. External Factors which may affect Outcomes

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

Description

•Inadequate funding and technical support from partnering institutions and cooperators •Inadequate input from conservation and wildlife groups, producers, and grain and livestock associations •Inadequate moisture (rainfall, snowpack, irrigation) to conduct the studies and creating too much variability •Interruptions in program development •Reduced numbers of staff and part time assistants to maintain appropriate progress on the project

V(K). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- After Only (post program)
- Retrospective (post program)

Description

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

2. Data Collection Methods

- Sampling
- Journals

Description

Data collection will be obtained through surveys at meetings, conventions, advisory boards and by direct contact.

V(A). Planned Program (Summary)**Program #2****1. Name of the Planned Program**

Integrated Pest Management

2. Brief summary about Planned Program

Montana producers are asking for more environmentally friendly products or methods to control pests. Weeds, diseases, and insects continually challenge producers who are often producing crops under less than ideal conditions. 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 of the quality of soil, air, and water is mandating less reliance on traditional pesticides and more research into biological control systems as part of a broader suite of management options. Foreign trade partners especially want decreased pesticide residues in the wheat and barley commodities being exported to their countries.

Research Activities: Integrated pest management projects at MSU tend to be long-term with little change from year to year. IPM programs in Montana seek to optimize grower profitability and natural resource sustainability through the development, selection, and implementation of economically sound and environmentally acceptable pest management strategies. Addressing the stakeholder's concern about pest control measures affecting food safety and food quality, MSU is continuing research into less chemically dependent systems. An emphasis on pest monitoring (using decision-making guidelines, and determining economic injury levels) will continue to result in substantial economic benefits and optimize the use of pesticides for controlling pests. Management of diseases of sugar beets and potatoes has been a major focus of research and outreach education programs. 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. Alfalfa hay management programs have been initiated to look at traditional use of chemical control methods, non-chemical control methods, biological controls, and cultural management options. Research into forages includes the examination of pest and natural enemy complexes and their interaction. Herbicide screening trials will continue to be established to assess the effectiveness of new and existing herbicides under the range of environmental and crop conditions representative of Montana agricultural systems. Research is ongoing to find additional environmentally friendly solutions for the management of soilborne plant pathogens. Identifying optimal disease management strategies and establishing biological controls are priorities for producing potato, sugar beet, small grains, and other crops in Montana. 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. MSU's Seed laboratory provides testing services for State and Federal agencies, private seed companies, farmers, and ranchers to provide vital information on seed quality.

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			25%	
212	Pathogens and Nematodes Affecting Plants			25%	
213	Weeds Affecting Plants			10%	
215	Biological Control of Pests Affecting Plants			15%	
216	Integrated Pest Management Systems			25%	
	Total			100%	

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

1. Situation and priorities

In Montana, small grains represent about 72% of the cropped acres, alfalfa and other hay about 26%, and other crops 2%. Montana ranks 3rd in barley production in the U.S., 3rd in wheat production, and 6th in sugar beet production. Wheat and barley represent about 33% of the total agricultural receipts for the state. Montana producers are continually challenged to produce crops with limited resources, especially moisture. The addition of insect, disease and weed pests creates additional problems challenging producers to maintain a competitive position in the market. Producers have relied on traditional pesticides to economically reduce the direct impact pests have on food and fiber production. The pesticides are costly; however delaying or eliminating pest control options may not always be an option. Biological controls for insects, weeds, and diseases are becoming more important as traditional chemical control methods are under scrutiny or cancelled. The increase in public concern about food quality, 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. Foreign trade partners especially want decreased pesticide residues in the wheat and barley commodities being exported to their countries. IPM programs seek to:

- Address the economic feasibility and environmental impact of biological control practices.
- Address the public's concern about food safety
- Investigate crop rotation systems, crop production methods and water management
- Implement biological control practices and explore a multitude of science-based options as a part of those systems.
- Optimize grower profitability and natural resource sustainability

2. Scope of the Program

- In-State Research
- In-State Extension
- 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 to be produced
- Fulltime 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, chemical companies, and other agencies will continue to provide 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 basic research that targets 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
2009	0.0	0.0	65.0	0.0
2010	0.0	0.0	65.0	0.0
2011	0.0	0.0	65.0	0.0
2012	0.0	0.0	65.0	0.0
2013	0.0	0.0	65.0	0.0

V(F). Planned Program (Activity)

1. Activity for the Program

- Publications will be made available in print and online that provide pest control recommendations
- Regional management guides will be produced and updated
- Research results will be communicated through pesticide workshops and field days
- Research results will be used to support FIFRA Section 18c products labeling requests
- Results will be used to update pesticide applicator training materials
- Training materials will be updated for private and commercial pesticide applicators

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 ● Education Class ● 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)

1. Standard output measures

Target for the number of persons(contacts) to be reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
2009	300	150	0	0
2010	350	150	0	0
2011	350	150	0	0
2012	375	150	0	0
2013	375	150	0	0

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

Expected Patent Applications

2009 :0 2010 :1 2011 :0 2012 :1 2013 :1

3. Expected Peer Review Publications

Year	Research Target	Extension Target	Total
2009	5	0	5
2010	5	0	5
2011	5	0	5
2012	5	0	5
2013	5	0	5

V(H). State Defined Outputs

1. Output Target

- Number of research citations

2009 :10 2010 :10 2011 :10 2012 :10 2013 :10

- Multidisciplinary journal articles published

2009 2 2010 2 2011 :4 2012 4 2013 4

V(I). State Defined Outcome

O. No	Outcome Name
1	Quality in-depth training programs for continuing educational on integrated approaches to pest management.
2	New IPM options discovered and evaluated per year.
3	Number of broad-ranging stewardship practices implemented.
4	Passing rate percentage for pesticide application licenses.
5	New products registered.
6	Number of potential products/practices evaluated.

Outcome #1**1. Outcome Target**

Quality in-depth training programs for continuing educational on integrated approaches to pest management.

2. Outcome Type : Change in Knowledge Outcome Measure

2009 :3 **2010** :3 **2011** :3 **2012** :3 **2013** :3

3. Associated Institute Type(s)

•1862 Research

4. 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

Outcome #2**1. Outcome Target**

New IPM options discovered and evaluated per year.

2. Outcome Type : Change in Action Outcome Measure

2009 :1 **2010** :1 **2011** :1 **2012** :1 **2013** :1

3. Associated Institute Type(s)

•1862 Research

4. 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

Outcome #3**1. Outcome Target**

Number of broad-ranging stewardship practices implemented.

2. Outcome Type : Change in Condition Outcome Measure

2009 :1 **2010** :1 **2011** :1 **2012** :1 **2013** :1

3. Associated Institute Type(s)

•1862 Research

4. 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

Outcome #4

1. Outcome Target

Passing rate percentage for pesticide application licenses.

2. Outcome Type : Change in Knowledge Outcome Measure

2009 :70 2010 : 70 2011 : 70 2012 :70 2013 :70

3. Associated Institute Type(s)

•1862 Research

4. 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

Outcome #5

1. Outcome Target

New products registered.

2. Outcome Type : Change in Condition Outcome Measure

2009 :1 2010 : 1 2011 : 1 2012 :1 2013 :1

3. Associated Institute Type(s)

•1862 Research

4. 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

Outcome #6

1. Outcome Target

Number of potential products/practices evaluated.

2. Outcome Type : Change in Action Outcome Measure

2009 :3 2010 : 3 2011 : 3 2012 :3 2013 :3

3. Associated Institute Type(s)

•1862 Research

4. 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

V(J). Planned Program (External Factors)

1. External Factors which may affect Outcomes

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

Description

•Inadequate moisture (rainfall, irrigation, snowpack) for crops to be produced and creating too much variability •Inadequate funding and technical support from partnering institutions and cooperators •Lack of fulltime staff and part time assistants for the projects •Major interruptions in program development •Reduced support from grain associations, biological and chemical pest control companies and other agencies

V(K). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- Retrospective (post program)
- After Only (post program)

Description

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

2. Data Collection Methods

- Sampling
- Journals

Description

Data collection will be obtained through surveys at meetings, conventions, advisory boards and by direct contact.

V(A). Planned Program (Summary)**Program #3****1. Name of the Planned Program**

Sustainable Agriculture

2. Brief summary about Planned Program

Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. Researching new crops and finding new markets for existing crops are potential ways to enhance Montana's growth in sustainable agriculture. Farmers and ranchers in Montana have historically practiced sustainable activities due to the marginal opportunities for success in a semi-arid environment. Our priority to develop competitive, sustainable, and viable plant and animal systems for Montana stakeholders is reflected in the research.

Research Activities: To decrease Montana's primary dependence on small grains and forage crops, crop diversity studies are being conducted on the feasibility of growing a variety of crops including: pulse crops (pea, lentil, chickpea, and soybean), herbs, mustard, safflower, sunflower, canola, turf, and specialty grains. The development of specialty crops and products for natural rubber production and bio-energy are a key focus. Sustainable agriculture projects at MSU tend to be long-term with little change from year to year.

Rangeland constitutes an important and widely variable resource for livestock producers. Studies are established to further define grazing parameters that maintain profitable agricultural enterprises while sustaining ecological systems. Research continues into the value of sheep grazing, which currently provides an economically feasible and ecologically sustainable tool to restore landscapes heavily infested with non-native invasive plants and noxious weeds.

By the latter half of the 21st century, global climate change could jeopardize agriculture, forestry, crop production, and other industries dependent on the natural environment. Studies are established to quantify nitrous oxide gas release under several cropping and tillage systems. Several projects over the past years have looked at flora growing in or near the hot springs of Yellowstone National Park. 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.

Our stakeholders charge us to improve animal health, food safety, quality, and marketing opportunities through sustainable practices. Two major initiatives address the needs of Montana livestock producers: the Montana Sheep Institute (MSI) and the Montana Beef Network (MBN). The objective of the MSI is to develop and implement nontraditional strategies that will increase the competitiveness of Montana lamb and wool in world markets. The MBN was established to return additional revenue to cattle producers and meet consumer needs in Montana. Consumers, both domestic and international, are demanding more information about the beef they purchase, including the age and source of the animal and the health, nutrition, and handling management. With the MBN in place, Montana producers can more easily adapt to mandatory country of origin labeling (COOL) and national animal identification programs.

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			25%	
132	Weather and Climate			10%	
205	Plant Management Systems			15%	
206	Basic Plant Biology			20%	
213	Weeds Affecting Plants			15%	
215	Biological Control of Pests Affecting Plants			15%	
	Total			100%	

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

1. Situation and priorities

Montana is a rural state with a land area of 93 million acres and a population of 944,000. It has a strong crop and livestock industry with annual receipts of over \$2.3 billion. Small grains represent about 72% of the cropped acres, alfalfa and other hay about 26%; other crops account for the remaining 2%. A basic principle of sustainable agriculture is to investigate current agricultural practices and find economically feasible and environmentally friendly alternatives to current agricultural practices. These include optimizing the use of chemicals for pest control, using alternative tillage systems, and increasing crop diversity. Goals of sustainable agriculture are to reduce dependence on non-renewable resources (such as fuel, synthetic fertilizer and pesticides), to promote stable and more prosperous farming communities, and to provide more farm income. With the continuing rise in fuel prices, farming practices that reduce dependence on fuel will add to the profitability of the enterprise. This factor alone provides incentives to farmers to investigate sustainable agricultural methods. The effects of MSU research in sustainable agriculture have an immediate impact on crop and livestock planning for Montana producers. A shift to more efficient and profitable specialty crops has begun and will continue to generate major interest in the future. The use of the Internet for information dissemination has become an increasingly valuable tool in providing stakeholders with materials to assist in their decision-making. While meetings, interviews, and focus groups will continue to be used to gather information from stakeholders, the increasing use of computer modeling and surveys will add to data being collected. As technology advances and producers begin to rely more on computer access to information, the role of MSU research and extension will continue to increase in their importance and impact.

MSU priorities are to:

- Conduct research to determine the feasibility of growing a variety of crops including: pulse crops (pea, lentil, chickpea, and soybean), herb, mustard, safflower, sunflower, canola, turf, and specialty grains.
- Decrease Montana's primary dependence on small grains and forage crops
- Develop grazing recommendations for management of rangeland resources
- Find ways through sustainable agriculture to provide more profitable farm enterprises
- Promote stable and prosperous farm families and communities through the development of crop diversity and community agribusiness support
- Reduce dependence on non-renewable resources (e.g., fuel, synthetic fertilizers, and pesticides) and maximize efficiencies
- Research alternative pest control practices, including biological control for pests of forages, potatoes, small grains, and sugar beets.

2. Scope of the Program

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

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

1. Assumptions made for the Program

•Adequate moisture (rainfall, irrigation, snowpack) will be available for crops •Fulltime 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, chemical companies, and other agencies will continue to provide input into priorities and activities •Program development will proceed as planned without major interruptions

2. Ultimate goal(s) of this Program

•Determine practical rangeland grazing strategies for Montana livestock producers •Develop novel pest management systems for controlling insects, diseases, and weeds •Find and evaluate alternative sustainable fuel sources from agricultural products grown in Montana •Provide sustainable new cropping opportunities for Montana 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
2009	0.0	0.0	30.0	0.0
2010	0.0	0.0	30.0	0.0
2011	0.0	0.0	30.0	0.0
2012	0.0	0.0	30.0	0.0
2013	0.0	0.0	30.0	0.0

V(F). Planned Program (Activity)

1. Activity for the Program

•Communicate research results through field days, news releases and presentations at county and state meetings and conventions •Distribute results of research via the Internet. •Hold strategic planning discussions with state agricultural groups

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 ● Demonstrations ● One-on-One Intervention 	<ul style="list-style-type: none"> ● Newsletters

3. Description of targeted audience

•Alternative energy groups and state agricultural advisory committees •Crop and livestock producers in Montana
 •Montana wheat and barley committees, crop protection companies, fertilizer advisory committees, conservation tillage equipment companies •Participants in extension and commodity group meetings and conferences

V(G). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons(contacts) to be reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
2009	400	125	0	0
2010	500	125	0	0
2011	600	150	0	0
2012	700	150	0	0
2013	700	150	0	0

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

Expected Patent Applications

2009 :0 2010 :0 2011 :0 2012 :0 2013 :0

3. Expected Peer Review Publications

Year	Research Target	Extension Target	Total
2009	5	0	5
2010	5	0	5
2011	5	0	5
2012	5	0	5
2013	5	0	5

V(H). State Defined Outputs

1. Output Target

- Number of research citations

2009 :5 2010 :8 2011 :8 2012 :10 2013 :10

V(I). State Defined Outcome

O. No	Outcome Name
1	Number of interactive meetings with state groups and agencies.
2	Number of producers per year implementing new farm management and budgeting practices.
3	Increased number of new crops adapted to Montana through percent acres increased.
4	Number of field days, news releases and presentations at conventions.
5	Number of new producers per year adopting measures to improve agricultural efficiency (e.g. better seed quality, higher numbers of fields with soil tested, optimization of fertilizer use).
6	Percent increase in acres per year of alternative crops compared to wheat and barley.

Outcome #1**1. Outcome Target**

Number of interactive meetings with state groups and agencies.

2. Outcome Type : Change in Knowledge Outcome Measure

2009 :10 2010 : 10 2011 : 10 2012 :10 2013 :10

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 121 - Management of Range Resources
- 205 - Plant Management Systems
- 213 - Weeds Affecting Plants

Outcome #2**1. Outcome Target**

Number of producers per year implementing new farm management and budgeting practices.

2. Outcome Type : Change in Action Outcome Measure

2009 :100 2010 : 100 2011 : 100 2012 :100 2013 :100

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 121 - Management of Range Resources
- 205 - Plant Management Systems
- 215 - Biological Control of Pests Affecting Plants

Outcome #3**1. Outcome Target**

Increased number of new crops adapted to Montana through percent acres increased.

2. Outcome Type : Change in Knowledge Outcome Measure

2009 :5 2010 : 5 2011 : 5 2012 :5 2013 :5

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 121 - Management of Range Resources
- 205 - Plant Management Systems
- 206 - Basic Plant Biology

Outcome #4**1. Outcome Target**

Number of field days, news releases and presentations at conventions.

2. Outcome Type : Change in Knowledge Outcome Measure

2009 :15 **2010** : 20 **2011** : 25 **2012** 30 **2013** :30

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 121 - Management of Range Resources
- 205 - Plant Management Systems
- 213 - Weeds Affecting Plants
- 215 - Biological Control of Pests Affecting Plants

Outcome #5

1. Outcome Target

Number of new producers per year adopting measures to improve agricultural efficiency (e.g. better seed quality, higher numbers of fields with soil tested, optimization of fertilizer use).

2. Outcome Type : Change in Action Outcome Measure

2009 :100 **2010** : 100 **2011** : 100 **2012** :100 **2013** :100

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 121 - Management of Range Resources
- 205 - Plant Management Systems
- 213 - Weeds Affecting Plants
- 215 - Biological Control of Pests Affecting Plants

Outcome #6

1. Outcome Target

Percent increase in acres per year of alternative crops compared to wheat and barley.

2. Outcome Type : Change in Condition Outcome Measure

2009 5 **2010** : 5 **2011** : 5 **2012** 5 **2013** :5

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 121 - Management of Range Resources
- 205 - Plant Management Systems
- 206 - Basic Plant Biology
- 213 - Weeds Affecting Plants
- 215 - Biological Control of Pests Affecting Plants

V(J). Planned Program (External Factors)

1. External Factors which may affect Outcomes

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

Description

•Inadequate moisture (rainfall, snowpack, irrigation) for crops to be produced creating too much variability •Inadequate funding and technical support from partnering institutions and cooperators •Lack of fulltime 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 (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- During (during program)
- Retrospective (post program)

Description

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

2. Data Collection Methods

- Mail

Description

Data collection will be obtained through surveys, conventions, and advisory boards at meetings and by direct contact.

V(A). Planned Program (Summary)**Program #4****1. Name of the Planned Program**

Biobased Products and Processing

2. Brief summary about Planned Program

The future of Montana's agricultural economy depends on maximizing net returns per acre or per animal unit with the most efficient use of resources. MSU is a leader in biobased research and development of novel product end-uses. A biobased, diversified economy will contribute to the economic development, providing in-state manufacturing, product development, rural development, and jobs. Value-added, agriculturally-based end products can create unique markets and enhanced revenues for producers. Since Montana exports approximately 85% of its raw commodities, it is increasingly important to capture their inherent economic value by adding value to raw agricultural commodities and processed food products before they leave the State. The development of bioenergy alternatives will also provide opportunities for renewable biobased products and will help to reduce the current dependence on fossil fuels. The revitalization of agriculture and rural communities in Montana is essential for our economic sustainability and competitiveness.

Research Activities: The goal of the Biobased Products Institute (BPI) is to build a biobased economy that provides opportunities and marketing strategies for Montana produced commodities. BPI currently supports 26 biobased research projects and has developed several high-value biobased products. Biobased products and processing projects at MSU tend to be long-term with little change from year to year. Research continues into developing alternative crops in Montana. Canola, chickpea, fenugreek, camelina, and assorted herbs have been evaluated for their potential in emerging value-added markets.

Oilseeds (including *Camelina sativa*, canola, soybeans, and safflower) are rapidly emerging as important Montana crops for production of culinary oils, biolubricants, omega-3 oils, feeds, and biodiesel. Over 90 germplasm accessions of camelina have been evaluated for adaptability, yield potential, and fatty acid content. Camelina production could significantly reduce the cost of biodiesel and provide a source for omega-3 oil, which is being evaluated for human consumption. BPI provides funding to support food risk assessment research and education, provides expertise to growers, researchers, and agricultural businesses, and assists in the development and marketing of safe, nutritious, and value-added products. Additional initiatives will provide new insights into food safety and risk assessment, including the use of vegetable oils as feedstock for fuel cells, the development of new wheat varieties, non-corrosive biobased de-icers, and the optimization of ethanol production from various feedstocks. The use of transgenic crops presents questions regarding the potential risk to human health and the environment. Computer modeling and data from greenhouse and field experiments will help in risk assessments to estimate what hazards may be associated with transgenic crops.

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
502	New and Improved Food Products			35%	
511	New and Improved Non-Food Products and Processes			35%	
605	Natural Resource and Environmental Economics			10%	
711	Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources.			20%	
	Total			100%	

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

1. Situation and priorities

The revitalization of agriculture and rural communities in Montana is essential for the state's economic sustainability and competitiveness. A biobased, diversified economy will provide in-state manufacturing, product development, rural development and jobs. The Biobased Products Institute (BPI) through the Board of Directors funds research projects that strives to increase the profitability of Montana agriculture, enhance the health of the human population, and reduce our reliance on non-renewable energy by the production of biofuels, ethanol, and biolubricants. A prime emphasis of our research is to add value to existing Montana products and to commercialize new products, while maximizing limited resources and reducing reliance on commodity agriculture. The priorities of BPI are to:

- Assist in development of safe, nutritious, value-added products, risk assessment, and marketing
- Develop an innovative and responsive program to enhance the developing needs of the State of Montana and Pacific Northwest/Northern High Plains regions
- Expand development and production of value-added products in Montana
- Provide expertise to growers, researchers and agricultural businesses
- Support food risk assessment research and education

2. Scope of the Program

- In-State Research
- In-State Extension

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

1. Assumptions made for the Program

•Adequate moisture (rainfall, irrigation, snowpack) will be available for crops to be produced

•Funding from industry organizations, grain and livestock associations, chemical companies, and other agencies will continue to provide input into priorities and activities

•Fulltime staff and part time assistants will be available to maintain appropriate progress

•Funding and technical support will be maintained from partnering institutions and cooperator

•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

- Build a biobased economy that provides manufacturing, product development, rural development, job opportunities and an opportunity to raise farm and ranch incomes
- Develop safe, nutritious, value-added products for 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
2009	0.0	0.0	8.0	0.0
2010	0.0	0.0	8.0	0.0
2011	0.0	0.0	8.0	0.0
2012	0.0	0.0	8.0	0.0
2013	0.0	0.0	8.0	0.0

V(F). Planned Program (Activity)

1. Activity for the Program

Several products are being produced and marketed by private industry, LLC, or grower cooperatives in Montana. Collaborators have expertise in incubating new businesses and new products, as well as assisting existing enterprises in product expansion.

The Institute will:

- Conduct outreach activities related to biobased products
- Develop systems that ensure food safety and agricultural security
- 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 mechanisms to enhance agricultural production practices to enhance product quality
- Use technology and biotechnology to improve plant and animal production systems

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 ● Group Discussion 	<ul style="list-style-type: none"> ● Newsletters

3. Description of targeted audience

- Alternative energy groups and state agricultural advisory committees
- Crop and livestock producers in Montana
- Economic development groups
- Participants in extension and commodity group meetings, conventions, and conferences
- State of Montana, Montana Department of Agriculture, Bureau of Land Management, USFS, and other government entities

V(G). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons(contacts) to be reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
2009	125	50	0	0
2010	150	50	0	0
2011	200	50	0	0
2012	250	50	0	0
2013	250	50	0	0

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

Expected Patent Applications

2009 :0 2010 :1 2011 :0 2012 :1 2013 :1

3. Expected Peer Review Publications

Year	Research Target	Extension Target	Total
2009	5	0	5
2010	5	0	5
2011	5	0	5
2012	5	0	5
2013	5	0	5

V(H). State Defined Outputs

1. Output Target

- New business partnerships created

2009 :1 2010 :1 2011 :1 2012 :1 2013 :1

- Number of research citations

2009 :8 2010 :10 2011 :10 2012 :12 2013 :12

V(I). State Defined Outcome

O. No	Outcome Name
1	Number of SBIR funding proposals submitted to federal agencies.
2	Number of opportunities and value-added programs introduced in Montana through continued education, research, and partnering with non-university personnel.
3	Number of new products with value-added potential evaluated per year within Montana.
4	Number of new food safety recommendations developed for consumers, which add value and provide for new uses of Montana's agricultural products.
5	New or expanded business and/or partnerships created inside and outside of Montana.

Outcome #1

1. Outcome Target

Number of SBIR funding proposals submitted to federal agencies.

2. Outcome Type : Change in Knowledge Outcome Measure

2009 :1 **2010 : 1** **2011 : 1** **2012 :1** **2013 :1**

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 502 - New and Improved Food Products
- 511 - New and Improved Non-Food Products and Processes

Outcome #2

1. Outcome Target

Number of opportunities and value-added programs introduced in Montana through continued education, research, and partnering with non-university personnel.

2. Outcome Type : Change in Action Outcome Measure

2009 :2 **2010 : 2** **2011 : 2** **2012 :2** **2013 :2**

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 502 - New and Improved Food Products
- 511 - New and Improved Non-Food Products and Processes

Outcome #3

1. Outcome Target

Number of new products with value-added potential evaluated per year within Montana.

2. Outcome Type : Change in Knowledge Outcome Measure

2009 :1 **2010 : 1** **2011 : 1** **2012 :1** **2013 :1**

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 502 - New and Improved Food Products
- 511 - New and Improved Non-Food Products and Processes

Outcome #4

1. Outcome Target

Number of new food safety recommendations developed for consumers, which add value and provide for new uses of Montana's agricultural products.

2. Outcome Type : Change in Action Outcome Measure

2009 :2 **2010 :2** **2011 :2** **2012 :2** **2013 :2**

3. Associated Institute Type(s)

- 1862 Research

4. Associated Knowledge Area(s)

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

Outcome #5

1. Outcome Target

New or expanded business and/or partnerships created inside and outside of Montana.

2. Outcome Type : Change in Condition Outcome Measure

2009 :1 **2010 :1** **2011 :1** **2012 :1** **2013 :1**

3. Associated Institute Type(s)

- 1862 Research

4. Associated Knowledge Area(s)

- 502 - New and Improved Food Products
- 605 - Natural Resource and Environmental Economics
- 711 - Ensure Food Products Free of Harmful Chemicals, Including Residues from Agricultural and Other Sources.

V(J). Planned Program (External Factors)

1. External Factors which may affect Outcomes

- Appropriations changes
- Economy
- Public Policy changes

Description

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

V(K). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- Retrospective (post program)
- During (during program)

Description

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

2. Data Collection Methods

- Unstructured

Description

Data collection will be obtained through surveys at meetings, conventions, advisory boards, and by direct contact.

V(A). Planned Program (Summary)**Program #5****1. Name of the Planned Program**

Plant Breeding, Genetics and Genomics

2. Brief summary about Planned Program

MSU is a recognized international leader in the development of new varieties of wheat and barley that are sought by buyers around the globe. An aggressive plant breeding program ensures development of higher yielding, disease- and insect-resistant wheat and barley cultivars. Researchers evaluate germplasm and identity traits that will produce higher quality wheat and barley to meet increasing demands for quality and for alternative uses, while maintaining yields. Many new cultivars are licensed with partnering companies, thus ensuring that Montana stakeholders receive maximum benefit from research discoveries. Additional work in the development of alternative crops continues to produce potential new market opportunities for Montana producers.

Research Activities: Plant breeding, genetics and genomics projects at MSU tend to be long-term with little change from year to year. The development and distribution of high quality, drought tolerant barley varieties that provide the highest possible production potential is a priority of barley breeding programs. Research is being conducted on the development of lines for the malting, feed and ethanol industries. Our understanding has increased of the genetic control of traits like winter hardiness, feed quality, malting quality, and drought tolerance. Montana crop producers want improved hard red and hard white winter wheat cultivars that are adapted to Montana conditions and suitable for both domestic and export markets. Research is being conducted on winter wheat cultivars to develop germplasm with excellent end-use qualities and resistance to important environmental stresses. The research results will increase the competitiveness of Montana wheat producers through improved winter wheat varieties with enhanced yield potential, pest resistance, and end-use qualities. 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 varieties for Montana producers, contribute to the science of wheat breeding and genetics, and improve end-use characteristics.

Research studies examine the degree to which the puroindoline proteins control wheat grain hardness and cereal quality and what alterations can be made to generate desired milling and end-product quality. Efforts have also been made to develop new grass varieties and a new sainfoin cultivar. 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. Plant viruses are used as protein cage architectures for the synthesis of nanomaterials. Projects are in place to use plant viruses as biotemplates for the fabrication of nanomaterials with applications in agriculture, medicine, and material sciences. The advances made have demonstrated that it is possible to modify plant viruses and other protein cage architectures to impart novel functions.

3. Program existence : New (One year or less)

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 and Biodiversity			35%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			10%	
204	Plant Product Quality and Utility (Preharvest)			30%	
205	Plant Management Systems			10%	
	Total			100%	

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

1. Situation and priorities

An aggressive plant breeding program ensures development of higher yielding, disease- 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 varieties 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, or loaves. Wheat cultivars developed at MSU and grown commercially by Montana producers continue to rank in the most preferred category by international customers.

Priorities in the Plant Breeding, Genetics, and Genomics Program Area include:

- Increase yield potentials and maintain/improve quality
- Improve winterhardiness, 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

- Multistate Research
- In-State 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, chemical companies, and other agencies will provide input into priorities and activities
- Fulltime staff and part time assistants will be available to maintain appropriate progress
- Funding and technical support will be maintained from partnering institutions and agricultural groups
- 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

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
2009	0.0	0.0	30.0	0.0
2010	0.0	0.0	30.0	0.0
2011	0.0	0.0	30.0	0.0
2012	0.0	0.0	30.0	0.0
2013	0.0	0.0	30.0	0.0

V(F). Planned Program (Activity)

1. Activity for the Program

•Communication of information on plant breeding and genomics advances through classroom activities, field days, variety trials, news releases, presentations at county and state meetings and conventions •Release germplasm, new varieties and new genomics tools and techniques •Strategic planning with state agricultural groups •Technical and non-technical publications

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"> ● Demonstrations 	<ul style="list-style-type: none"> ● Public Service Announcement ● 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

V(G). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons(contacts) to be reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
2009	2000	500	0	0
2010	2000	500	0	0
2011	2000	500	0	0
2012	2000	500	0	0
2013	2000	500	0	0

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

Expected Patent Applications

2009 :1 2010 :0 2011 :1 2012 :0 2013 :0

3. Expected Peer Review Publications

Year	Research Target	Extension Target	Total
2009	5	0	5
2010	5	0	5
2011	5	0	5
2012	5	0	5
2013	5	0	5

V(H). State Defined Outputs

1. Output Target

- Number of foreign trade teams in Montana

2009 :15 2010 :15 2011 :20 2012 :20 2013 :20

- Number of foreign trade teams at MSU

2009 :4 2010 :4 2011 :4 2012 :4 2013 :4

- Number of research citations

2009 :14 2010 :16 2011 :18 2012 :20 2013 :20

V(I). State Defined Outcome

O. No	Outcome Name
1	Electronic documents on new cultivars and Montana district recommendations provided to Montana producers to maintain Montana producers' dominance in small grain markets.
2	The number of new molecular techniques used to enhance breeding results.
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	Number of improved variety recommendations by districts across Montana.
6	Planted acreage percentage increase per year of new MSU-released small grains in Montana.

Outcome #1**1. Outcome Target**

Electronic documents on new cultivars and Montana district recommendations provided to Montana producers to maintain Montana producers' dominance in small grain markets.

2. Outcome Type : Change in Knowledge Outcome Measure

2009 :100

2010 : 100

2011 : 100

2012 :100

2013 :100

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

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

Outcome #2**1. Outcome Target**

The number of new molecular techniques used to enhance breeding results.

2. Outcome Type : Change in Action Outcome Measure

2009 :1

2010 : 1

2011 : 1

2012 :1

2013 :1

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

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

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

2009 :1

2010 : 0

2011 : 1

2012 : 0

2013 :0

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

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

Outcome #4**1. Outcome Target**

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

2. Outcome Type : Change in Knowledge Outcome Measure**2009** :100**2010** : 100**2011** : 100**2012** :100**2013** :100**3. Associated Institute Type(s)**

- 1862 Research

4. Associated Knowledge Area(s)

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

Outcome #5**1. Outcome Target**

Number of improved variety recommendations by districts across Montana.

2. Outcome Type : Change in Action Outcome Measure**2009** 5**2010** : 5**2011** : 5**2012** 5**2013** :5**3. Associated Institute Type(s)**

- 1862 Research

4. Associated Knowledge Area(s)

- 201 - Plant Genome, Genetics, and Genetic Mechanisms
- 202 - Plant Genetic Resources and Biodiversity
- 203 - Plant Biological Efficiency and Abiotic Stresses Affecting Plants
- 205 - Plant Management Systems

Outcome #6**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**2009** 3**2010** : 3**2011** : 3**2012** 3**2013** :3**3. Associated Institute Type(s)**

- 1862 Research

4. Associated Knowledge Area(s)

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

- 205 - Plant Management Systems

V(J). Planned Program (External Factors)

1. External Factors which may affect Outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Other (Funding)

Description

•Inadequate funding and technical support from partnering institutions and cooperators •Inadequate moisture (rainfall, irrigation, snowpack) for crops to be produced and creating too much variability •Lack of fulltime 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 (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- Retrospective (post program)
- During (during program)

Description

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 Montana Wheat and Barley Committee.

2. Data Collection Methods

- Unstructured
- On-Site

Description

Data collection will be obtained through surveys at meetings, conventions, advisory boards, and by direct contact.

V(A). Planned Program (Summary)**Program #6****1. Name of the Planned Program**

Animal Health

2. Brief summary about Planned Program

Maintaining high quality meat, milk, and fiber products from Montana livestock is a major focus. Losses due to environmental stresses, diseases, and mortality create the need for an improved understanding of the factors affecting Montana livestock. Disease control and the improvement of livestock performance affect all livestock producers in their ability to raise healthy stock and reduce economic losses. Producing high quality animals and obtaining the highest profit potential are essential for Montana to maintain or exceed its current ranks in the national cattle and sheep industry. 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 vaccines, important diseases may be managed more effectively.

Research Activities: Specific projects have been established to investigate diseases and animal productivity in cattle, sheep, and bison. Animal health projects at MSU tend to be long-term with little change from year to year. Any advances that can be made in improving cattle and sheep output economically benefits all Montana livestock producers. Bison research focuses on the development of efficacious brucellosis vaccines. A better understanding of the mechanisms involved in the spread of brucellosis directly addresses concerns of cattle producers in areas near Yellowstone National Park (YNP) and could aid in the management of bison by YNP wildlife managers. Cattle research focuses on disease control, reproductive enhancement, and animal productivity. Programs are in place to investigate vaccines for rotavirus, prion diseases, coccidiosis, herpesviruses, and mastitis in cattle. Research continues into winter maintenance programs for cattle and sheep to improve performance and reduce stress caused by diseases and losses. The Montana Sheep Institute (MSI) is a cooperative project between Montana Wool Growers Association and MSU dedicated to developing and implementing non-traditional strategies that will increase the competitiveness of Montana's lamb and wool in the world market. Our goal is to explore integrated pest management (IPM) opportunities to increase the use of sheep in weed management programs, to improve the profitability and competitiveness of the Montana sheep industry, and to provide marketing opportunities for Montana sheep producers. Equine strangles continues to be a problem to horse health and industry, despite the widespread use of commercial vaccines. Researchers are investigating the roles of antigenic cell surface proteins of *S. equi* in their contribution to disease in horses. Studies are being conducted to determine the potential for the development of vaccines for West Nile and bluetongue viruses. Research is being established to understand the cause and development of and immunity to bovine shipping fever and to develop novel strategies for the prevention and control of this disease complex.

3. Program existence : New (One year or less)

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			10%	
301	Reproductive Performance of Animals			10%	
302	Nutrient Utilization in Animals			10%	
303	Genetic Improvement of Animals			10%	
307	Animal Production Management Systems			10%	
311	Animal Diseases			35%	
315	Animal Welfare, Well-Being and Protection			10%	
902	Administration of Projects and Programs			5%	
	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. In addressing the needs of our stakeholders in Montana and those who rely on MSU's recommendations for animal production in the state, the following priorities have been established:

- Demonstrate ways to manage stress in animals during the winter, lower production costs, and improve beef genetics
- Develop and implement new management protocols and/or pharmaceutical and nutritional regimens that will increase the fertility of domestic ruminants
- Develop vaccines for Montana livestock that protect them against debilitating diseases
- Determine how factors, such as herd size and supplement intake, influence growth and development of cattle grazing native rangelands
- Evaluate barley cultivars in feeding studies to demonstrate their effect on improving feed efficiency and reducing feed costs
- Improve milk and beef production by targeting mutagenesis of cells in cattle bovine immune cells
- Test new natural oil additives for improving lamb meat characteristics to increase the competitiveness of U.S. lamb in the world market

2. Scope of the Program

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

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

1. Assumptions made for the Program

- Funding through industry organizations, livestock associations, chemical companies, and other agencies will continue to provide input into priorities and activities
- Fulltime staff and part time assistants will be available to maintain appropriate progress on the project
- 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

- Increase discovery of novel vaccines for prevention of livestock diseases
- Maintain our role as a leading university in animal genetics and rangeland stewardship research
- Provide genomic research that will help Montana producers stay competitive
- Provide improved production management recommendations to Montana 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
2009	0.0	0.0	100.0	0.0
2010	0.0	0.0	100.0	0.0
2011	0.0	0.0	100.0	0.0
2012	0.0	0.0	100.0	0.0
2013	0.0	0.0	100.0	0.0

V(F). Planned Program (Activity)

1. Activity for the Program

- Databases that are easily accessible by researchers and producers to make research results more readily available
- Papers and research results at state nutrition conferences, field days, county meetings and state conventions
- Research articles, fact sheets and news releases for scientists and state media
- Strategic planning meetings with state agricultural groups, including the Montana Stockgrowers Association and the Montana Board of Livestock

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 	<ul style="list-style-type: none"> ● Newsletters

3. Description of targeted audience

- Montana Department of Agriculture, animal health companies, and state commodity groups
- Montana Stockgrowers Association and the Montana Board of Livestock
- Ranchers, seedstock industry, colleagues and related stakeholders

V(G). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons(contacts) to be reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
2009	250	100	0	0
2010	250	100	0	0
2011	250	100	0	0
2012	250	100	0	0
2013	250	100	0	0

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

Expected Patent Applications

2009 :1 2010 :0 2011 :1 2012 :0 2013 :0

3. Expected Peer Review Publications

Year	Research Target	Extension Target	Total
2009	5	0	5
2010	5	0	5
2011	5	0	5
2012	5	0	5
2013	5	0	5

V(H). State Defined Outputs

1. Output Target

- Number of research citations

2009 :15 2010 :15 2011 :15 2012 :15 2013 :15

- Building built through donations

2009 0 2010 1 2011 :0 2012 0 2013 0

V(I). State Defined Outcome

O. No	Outcome Name
1	Identify critical infection and resistance processes.
2	Number of ranches per year adopting enterprise management of animal health issues.
3	Number of novel vaccines developed per year.
4	Number of activities per year that prevent disease outbreaks or manage diseases of Montana livestock.
5	Meetings that maintain or enhance Montana's presence in the production of quality meat products.

Outcome #1

1. Outcome Target

Identify critical infection and resistance processes.

2. Outcome Type : Change in Knowledge Outcome Measure

2009 :1 2010 : 1 2011 : 1 2012 :1 2013 :1

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

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

Outcome #2

1. Outcome Target

Number of ranches per year adopting enterprise management of animal health issues.

2. Outcome Type : Change in Action Outcome Measure

2009 :10 2010 : 10 2011 : 10 2012 :10 2013 :10

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 121 - Management of Range Resources
- 301 - Reproductive Performance of Animals
- 311 - Animal Diseases
- 315 - Animal Welfare, Well-Being and Protection

Outcome #3

1. Outcome Target

Number of novel vaccines developed per year.

2. Outcome Type : Change in Condition Outcome Measure

2009 :1 2010 : 0 2011 : 1 2012 :0 2013 :0

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

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

Outcome #4

1. Outcome Target

Number of activities per year that prevent disease outbreaks or manage diseases of Montana livestock.

2. Outcome Type : Change in Action Outcome Measure

2009 :1

2010 : 1

2011 : 1

2012 :1

2013 :1

3. Associated Institute Type(s)

- 1862 Research

4. Associated Knowledge Area(s)

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

Outcome #5**1. Outcome Target**

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

2. Outcome Type : Change in Condition Outcome Measure

2009 :1

2010 : 1

2011 : 1

2012 :1

2013 :1

3. Associated Institute Type(s)

- 1862 Research

4. 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

V(J). Planned Program (External Factors)**1. External Factors which may affect Outcomes**

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

Description

•Inadequate funding and technical support from partnering institutions and cooperators •Inadequate moisture (rainfall, irrigation, snowpack) for crops to be produced creating too much variability •Lack of fulltime 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 (Evaluation Studies and Data Collection)**1. Evaluation Studies Planned**

- During (during program)
- Retrospective (post program)
- Other (Review with state agencies)

Description

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

2. Data Collection Methods

- On-Site
- Journals
- Sampling

Description

Data collection will be obtained through surveys at meetings, conventions, advisory boards, and by direct contact.

V(A). Planned Program (Summary)**Program #7****1. Name of the Planned Program**

Agronomic and Forage Crops

2. Brief summary about Planned Program

Research programs in the COA range from basic research in genetics and biotechnology to practical applications in rangeland, forest, crop, and livestock management. Our long-term strategies are designed to make Montana agricultural products more desirable in U.S. and world markets. Summaries of survey information from the Montana Weed Coordinators have identified critical local research needs on the management of invasive plants on private, public and agency lands. This has led to new state funding initiatives and research and education alignment with the Montana Weed Management Plan. Projects in agronomic and forage research at MSU often contain objectives that interconnect with objectives in plant and animal genomics, and biobased and sustainable agriculture. Developing projects that meet more than one objective provides increased value to our stakeholders. Agronomic and forage crop projects at MSU are long-term with little change from year to year. Projects in the Agronomic and Forage Crops program area serve to provide new cropping opportunities, increased markets, and substantial economic benefit for Montana growers.

Research Activities: Surveys at Montana farm conferences indicated a strong interest in diversified crop rotations. Crop diversity studies continue to show promise for increasing on-farm receipts while reducing dependency on small grains. Diversifying dryland cropping systems that include oilseed and pulse crops in sequence with cereal crops is a viable and sustainable approach to crop production. Winter and spring peas, canola, corn, lentil, mustard, sunflower, triticale, and chickpea are included in long-term rotation studies. Research into new crops such as dwarf and slow-growing lawn grasses, native ornamental flowers, essential oils, and crops for natural rubber production and bio-energy are examples of research that will provide opportunities for growers and their communities. An evaluation of livestock distribution practices on grazed watersheds is part of a three-state project (MT, CA, OR) and shows the potential to manipulate cattle grazing patterns to protect and improve fishery and wildlife habitat. Grazing and fire recovery in rangelands are priority issues to be studied in Montana and Wyoming, especially in light of the large forest fires that occurred in Montana in 2006 and 2007. Grazing projects serve the need to provide economic and environmentally sensitive programs for Montana stakeholders. By determining the grazing behavior by cattle and the cattle's response, decisions can be made on the need for supplemental feed over winter months. Understanding the effect of solar radiation in the selection of winter grazing ranges can help improve a cow's ability to conserve energy in winter. A grazing study was completed to evaluate the effect of using goats and sheep as a cost effective strategy for controlling conifers that have encroached upon much of Montana's rangeland. This information will help refine browsing prescriptions and better enable range and livestock managers to effectively use prescribed browsing as a tool.

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			10%	
112	Watershed Protection and Management			10%	
121	Management of Range Resources			30%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			10%	
204	Plant Product Quality and Utility (Preharvest)			10%	
205	Plant Management Systems			30%	
	Total			100%	

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

1. Situation and priorities

Montana has limited crop and livestock diversity due to its semi-arid environment, a short growing season, and the potential for long and severe winters. Cattle and sheep are the primary livestock enterprises; small grains, forages and short season specialty crop make up the bulk of the cropping activity. With limited diversity, researchers at MSU are able to delve deeper into understanding each entity from production and management studies as well as through plant and animal genomics. Agricultural cash receipts in Montana total over \$2.3 billion annually and are made up of roughly a 55:45 mix of livestock and crops respectively. In addition, Montana is world-renowned for the quality of its wheat and beef cattle.

Priorities established in this program include to:

- Characterize and understand the complex interactive components of habitats that will lead to improved soil, plant and water resources
- Create better grazing management in concert with the preservation of riparian habitats, wildlife and clean water
- Demonstrate innovation in recommended approaches to crop and pest management
- Develop greater nutritional value for forages
- Develop higher disease and insect resistance in wheat and barley
- Develop higher yielding varieties
- Establish new value-added crops
- Establish research programs that provide more efficient use of natural resources, especially water

2. Scope of the Program

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

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

1. Assumptions made for the Program

- Adequate moisture (rainfall, irrigation, snowpack) will be available for crops to be produced
- Corporate funding organizations, grain and livestock associations, chemical companies, and other agencies will continue to provide input into priorities and activities
- Fulltime staff and part time assistants will be available to maintain appropriate progress on the project
- 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

•Create better grazing management recommendations to cattle producers •Develop higher disease and insect resistance in wheat and barley and greater nutritional value for forages •Develop higher yielding varieties and introduce new value-added crops •Provide crop management options and establish research programs that are consistent with environmental and sustainable agricultural objectives

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
2009	0.0	0.0	20.0	0.0
2010	0.0	0.0	20.0	0.0
2011	0.0	0.0	20.0	0.0
2012	0.0	0.0	20.0	0.0
2013	0.0	0.0	20.0	0.0

V(F). Planned Program (Activity)

1. Activity for the Program

•Development of research summaries and fact sheets •Training in cooperation with the Montana Hay Growers Association, Montana Alfalfa Seed Growers Association and Montana Seed Growers Association •Workshops and meetings with federal and state land management agencies

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"> ● Demonstrations ● Workshop 	<ul style="list-style-type: none"> ● Newsletters

3. Description of targeted audience

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

V(G). Planned Program (Outputs)

1. Standard output measures

Target for the number of persons(contacts) to be reached through direct and indirect contact methods

	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Year	Target	Target	Target	Target
2009	150	200	0	0
2010	175	200	0	0
2011	200	200	0	0
2012	225	200	0	0
2013	225	200	0	0

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

Expected Patent Applications

2009 :1 2010 :0 2011 :1 2012 :0 2013 :0

3. Expected Peer Review Publications

Year	Research Target	Extension Target	Total
2009	5	5	10
2010	5	5	10
2011	5	5	10
2012	5	5	10
2013	5	5	10

V(H). State Defined Outputs

1. Output Target

- Number of research citations

2009 :10 2010 :12 2011 :14 2012 :16 2013 :16

V(I). State Defined Outcome

O. No	Outcome Name
1	Number of new crops evaluated per year for adaptation potential in Montana.
2	Number of new crops and varieties adopted per year.
3	Increase in acres of non-traditional crops planted in Montana.
4	Number of routine field crop and forage samples processed by the MSU Seed Laboratory per year.
5	New grazing plans established for livestock and wildlife in rangeland environments.

Outcome #1

1. Outcome Target

Number of new crops evaluated per year for adaptation potential in Montana.

2. Outcome Type : Change in Knowledge Outcome Measure

2009 : 2 **2010** : 2 **2011** : 2 **2012** : 2 **2013** : 2

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 203 - Plant Biological Efficiency and Abiotic Stresses Affecting Plants
- 204 - Plant Product Quality and Utility (Preharvest)
- 205 - Plant Management Systems

Outcome #2

1. Outcome Target

Number of new crops and varieties adopted per year.

2. Outcome Type : Change in Action Outcome Measure

2009 : 1 **2010** : 1 **2011** : 1 **2012** : 1 **2013** : 1

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 203 - Plant Biological Efficiency and Abiotic Stresses Affecting Plants
- 204 - Plant Product Quality and Utility (Preharvest)
- 205 - Plant Management Systems

Outcome #3

1. Outcome Target

Increase in acres of non-traditional crops planted in Montana.

2. Outcome Type : Change in Condition Outcome Measure

2009 : 5000 **2010** : 5000 **2011** : 5000 **2012** : 5000 **2013** : 5000

3. Associated Institute Type(s)

•1862 Research

4. Associated Knowledge Area(s)

- 205 - Plant Management Systems

Outcome #4

1. Outcome Target

Number of routine field crop and forage samples processed by the MSU Seed Laboratory per year.

2. Outcome Type : Change in Action Outcome Measure

2009 :750 **2010** : 750 **2011** : 750 **2012** 750 **2013** :750

3. Associated Institute Type(s)

- 1862 Research

4. Associated Knowledge Area(s)

- 121 - Management of Range Resources
- 205 - Plant Management Systems

Outcome #5

1. Outcome Target

New grazing plans established for livestock and wildlife in rangeland environments.

2. Outcome Type : Change in Condition Outcome Measure

2009 :10 **2010** : 10 **2011** : 10 **2012** :10 **2013** :10

3. Associated Institute Type(s)

- 1862 Research

4. Associated Knowledge Area(s)

- 112 - Watershed Protection and Management
- 121 - Management of Range Resources
- 205 - Plant Management Systems

V(J). Planned Program (External Factors)

1. External Factors which may affect Outcomes

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

Description

•Inadequate funding and technical support from partnering institutions and cooperators •Inadequate moisture (rainfall, irrigation, snowpack) for crops to be producedand creating too much variability •Lack of fulltime 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 (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- After Only (post program)
- During (during program)

Description

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

2. Data Collection Methods

- Mail

Description

Data collection will be obtained through surveys at meetings, conventions, advisory boards, and by direct contact